VOLUME 3 www.herpetofauna.org NUMBER 1

AMPHIBIAN & REPTILE CONSERVATION

THE INTERNATIONAL JOURNAL DEVOTED TO THE WORLDWIDE PRESERVATION AND MANAGEMENT OF AMPHIBIAN AND REPTILIAN DIVERSITY

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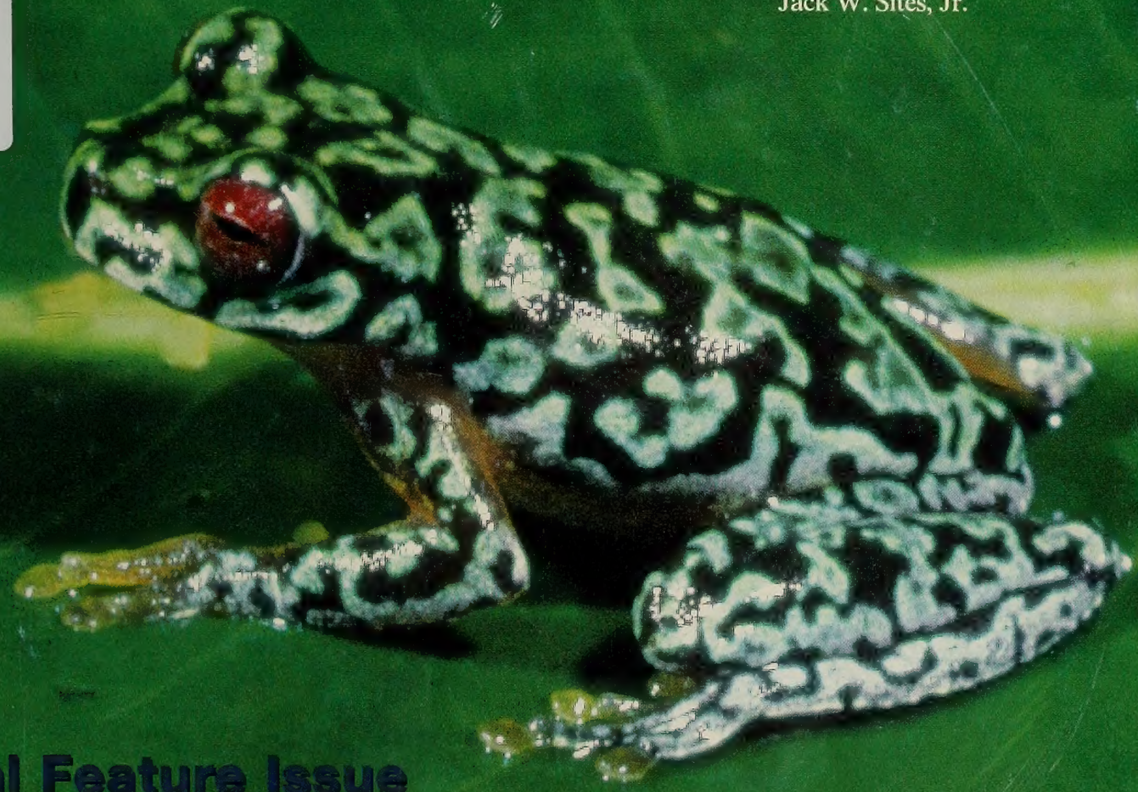

Special Feature Issue

HONDURAS

The Herpetofauna of the Cloud Forests of Honduras

The Conservation Status of the Herpetofauna of Honduras

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ISSN: 1083-446X ISSN (Online): 1525-9153

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Continued on inside back cover

Editorial

WORDS FROM THE EDITOR—The journal **Amphibian and Reptile Conservation** (**ARC**) has made many advances since our last published issue. A quick glance at this issue verifies again our continued commitment and resolve to publish a journal of the highest standards devoted exclusively to the conservation of amphibians and reptiles worldwide. To review let me elaborate further.

The journal is now open access. This means anyone with an Internet connection and web browser can access the contents of the journal free-of-charge with absolutely no restrictions and/or registration. Go to the PubMed Central website at http://www.pubmedcentral.nih.gov/, review the list of journals, and click on **Amphibian and Reptile Conservation**. The journal can be retrieved as either exact reproduction of the actual journal pages (PDF) and/or as HTML files. All the original photographs, tables, graphs, etc. are available online in high resolution for all the world to read, use, and exchange. The journal is also permanently archived (online) by PubMed Central at the National Library of Medicine (the world's largest medical library) [NLM] under the auspices of the US National Institutes of Health (NIH) and National Center for Biotechnology Information (NCBI).

ARC does not charge any fees whatsoever for an author(s) to publish in the journal. Authors publishing in the journal also retain full copyright to all their material. Furthermore, the journal will always be available in hard copy (printed edition) for those who prefer to read it in this format.

I feel it very important to elaborate on the importance of open access publishing. In a perfect world, all journals (and literature) would be open access. To advance scientific study and further the benefit to human health and especially environmental conservation (Fonseca and Benson 2003). It is imperative for organizations, societies, and publishers to advance the open access model for scientific publication. In a recent 194-page report of the STM (Science, Technical, and Medical) journal industry by Sami Kassab financial analysts at BNP Paribas (http://www.bnpparibas.com/en/home/default.asp) it warned about the impact of changes in the scientific publishing industry (BioMedCentral 2003a). It was estimated in the report that the global scientific research community could save more than 40% in costs by switching entirely to an open-access model.

Societies should continue to increase organizational functions and offer an ever-increasing number of member benefits separate and therefore outside of the publication(s) aspect. In this way, being a society member is a valued benefit separate from receiving the publication(s). At the very least, members should be able to access the societies publications full-text online from home. I am a member of several scientific societies but cannot access their content online from home; academic libraries are where I need to go now for online access.

Another added benefit for publications online is their inherent ability to link to the full-text of other publications and websites. This is a must in the electronic age we are heading into full force (CrossRef [www.crossref.org] and PubMed Central [www.pubmedcentral.nih.org]). For example, reading the most recent articles from **ARC** one directly links to *Proceedings of the National Academy of Sciences of the United States of America*, AmphibiaWeb, and other articles, abstracts, and important resources indexed and linked to the PubMed database. Other important areas in an open access environment also become a reality such as data mining and the use of the Digital Object Identifier (DOI) [DeRisi, et al. 2003].

I support science and scientific societies, which advance our knowledge of life on earth and all of scientific study in general. I am especially partial to the Herpetologists' League and Herpetologica for it was the first science journal in the field of herpetology I was exposed to. I remember riding my modest Stingray bicycle 10 or 12 miles one way just to see the only library in my area that had a subscription to Herpetologica! In the electronic age, which is upon us and growing greater everyday, this type of effort is very impractical. It is especially important for people in developing countries to have good information available online for this is where the most urgent conservation work is being conducted (BioMed Central. 2003b).

The future is ready to explode further into the Information Age caused primarily by the Internet and is thus literally changing the landscape of scientific publishing (Doyle, et al. 2003). It is in the best interest of science and the public to make the necessary steps toward the noble goal of open access of knowledge (online) surely to advance society and surpass any of our wildest dreams. The solutions to global warming, species extinctions, developmental malformations as seen for example in some amphibian species, will offer humankind unimagined advancements in every field due to the uninhibited exchange of information online. The brave, noble, and solution solvers now and in the future will remain at the forefront of this exciting human endeavor called open access.—*Craig Hassapakis*

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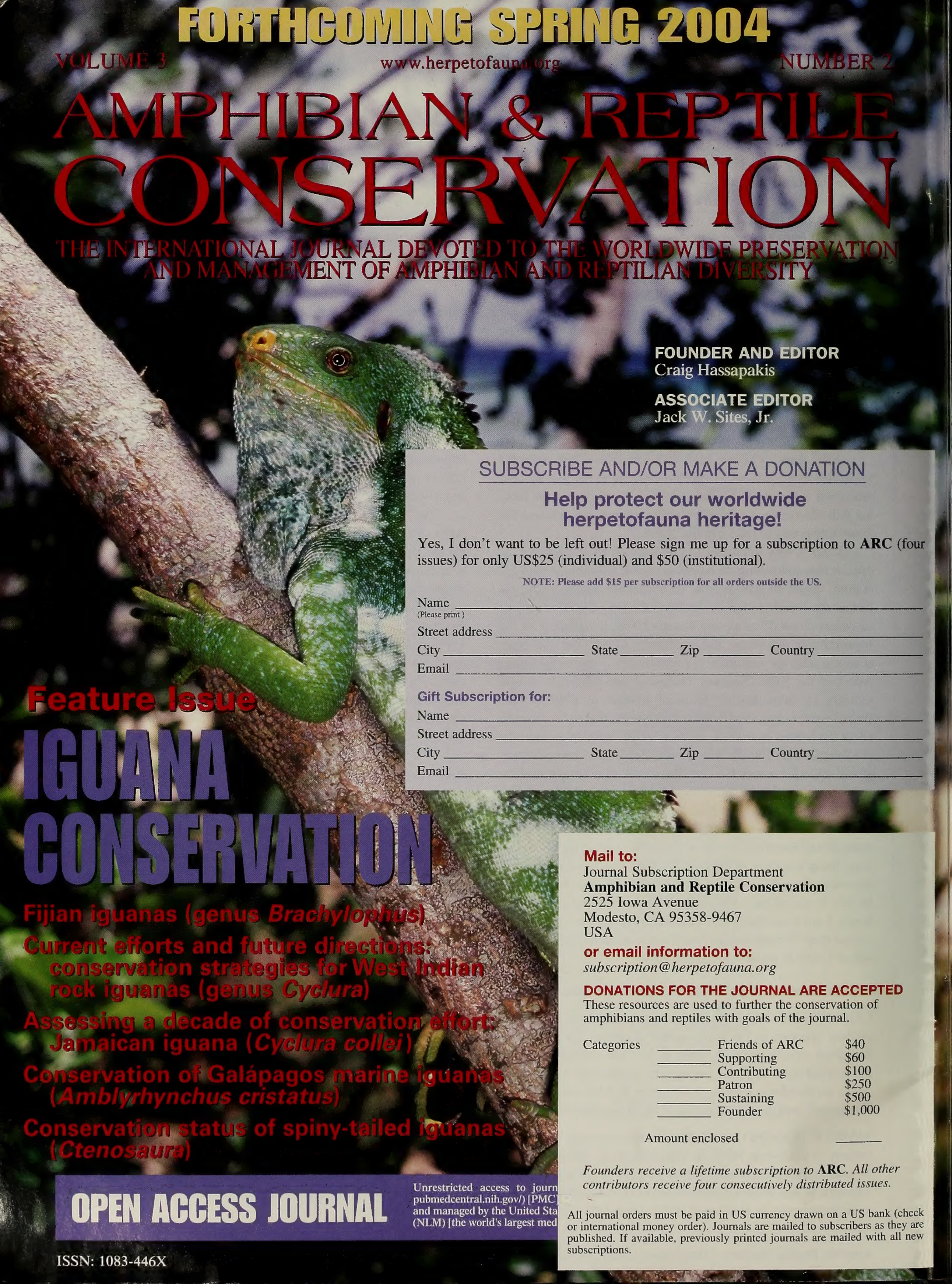
Authors

LARRY DAVID WILSON is a recognized authority on the reptiles and amphibians of Honduras, based on three and one-half decades of field experience. He is the author of about 230 publications in his field, including the recently published *The Amphibians of Honduras*, coauthored with James R. McCranie. He is also a professor of biology at Miami-Dade College in Miami, Florida, where he has worked since 1972. He has traveled extensively in Mexico and Central America, especially Honduras. He is currently working on books on Honduran reptiles (with James R. McCranie), the herpetofauna of the Honduran Mosquitia (with McCranie and Josiah H. Townsend), and the herpetofauna of the Bay Islands and Cayos Cochinos of Honduras (with McCranie and Gunther Köhler).

JAMES R. (RANDY) MCCRANIE is also a recognized authority on the herpetofauna of Honduras, the result of more than a quarter century of fieldwork. He is the author of about 160 papers in the field of herpetology and is the senior author of *The Amphibians of Honduras*. He recently retired from 30 years of service with the U.S. Postal Service. His field experience is as extensive as is Wilson's; although he and Wilson usually travel to Honduras together, McCranie has made a number of trips by himself. He is involved with the same three books as mentioned above, being senior author on two of them.



FORTHCOMING SPRING 2004

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AMPHIBIAN & REPTILE CONSERVATION

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Feature Issue

IGUANA CONSERVATION

Fijian iguanas (genus *Brachylophus*)

Current efforts and future directions: conservation strategies for West Indian rock iguanas (genus *Cyclura*)

Assessing a decade of conservation effort: Jamaican iguana (*Cyclura collei*)

Conservation of Galápagos marine iguanas (*Amblyrhynchus cristatus*)

Conservation status of spiny-tailed iguanas (*Ctenosaura*)

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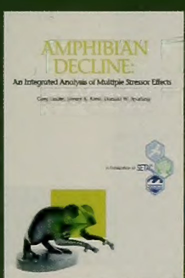
Two seminal works essential to understanding amphibians and reptiles



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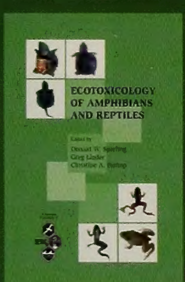

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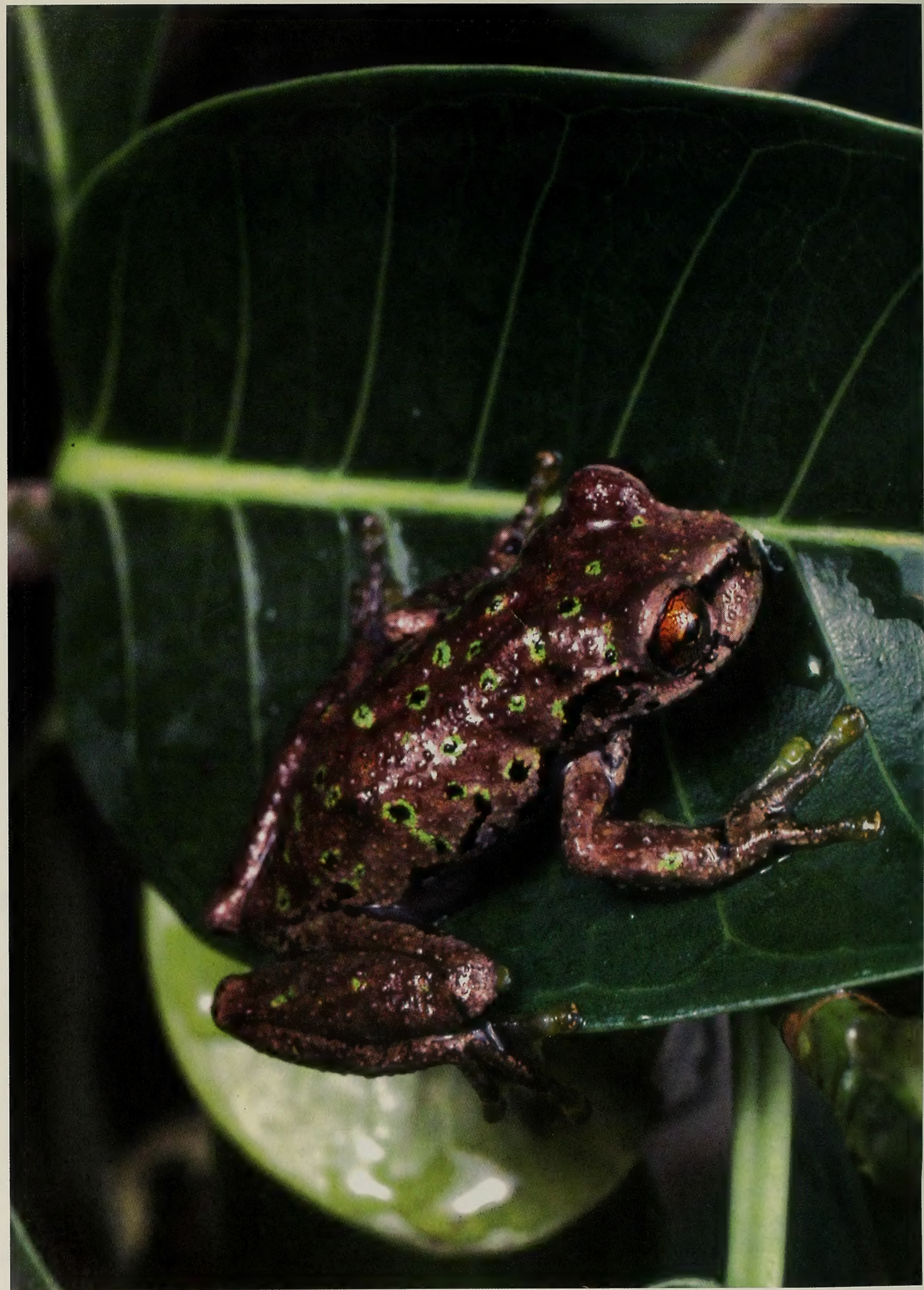

Plate 1. *Plectrohyla dasypus*. A Honduran endemic with all known populations believed to be declining.
DOI: 10.1514/journal.arc.0000012.g001

Amphibian and Reptile Conservation 3(1):6-33.
DOI: 10.1514/journal.arc.0000012 (1004KB)

The conservation status of the herpetofauna of Honduras

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***Abstract.*—The conservation status of the members of the Honduran herpetofauna is discussed. Based on current and projected future human population growth, it is posited that the entire herpetofauna is endangered. The known herpetofauna of Honduras currently consists of 334 species, including 117 amphibians and 217 reptiles (including six marine reptiles, which are not discussed in this paper). The greatest number of species occur at low and moderate elevations in lowland and/or mesic forest formations, in the Northern and Southern Cordilleras of the *Serranía*, and the ecophysiographic areas of the Caribbean coastal plain and foothills. Slightly more than one-third of the herpetofauna consists of endemic species or those otherwise restricted to Nuclear Middle America. Honduras is an area severely affected by amphibian population decline, with close to one-half of the amphibian fauna threatened, endangered, or extinct. The principal threats to the survival of members of the herpetofauna are uncontrolled human population growth and its corollaries, habitat alteration and destruction, pollution, pest and predator control, overhunting, and overexploitation. No Honduran amphibians or reptiles are entirely free of human impact. A gauge is used to estimate environmental vulnerability of amphibian species, using measures of extent of geographic range, extent of ecological distribution, and degree of specialization of reproductive mode. A similar gauge is developed for reptiles, using the first two measures for amphibian vulnerability, and a third scale for the degree of human persecution. Based on these gauges, amphibians and reptiles show an actual range of Environmental Vulnerability Scores (EVS) almost as broad as the theoretical range. Based on the actual EVS, both amphibian and reptilian species are divided into three categories of low, medium, and high vulnerability. There are 24 low vulnerability amphibians and 47 reptiles, 43 medium vulnerability amphibians and 111 reptiles, and 50 high vulnerability amphibians and 53 reptiles. Theoretical EVS values are assessed against available information on current population status of endemic and Nuclear Middle American taxa. Almost half (48.8%) of the endemic species of Honduran amphibians are already extinct or have populations that are in decline. Populations of 40.0% of the Nuclear Middle American amphibian species are extirpated or in decline. A little less than a third (27.0%) of the endemic reptiles are thought to have declining populations. Almost six of every ten (54.5%) of the Nuclear Middle American reptilian species are thought to have declining populations. EVS values provide a useful indicator of potential for endangerment, illustrating that the species whose populations are currently in decline or are extinct or extirpated have relatively high EVS. All high EVS species need to be monitored closely for changes in population status. A set of recommendations are offered, assuming that biotic reserves in Honduras can be safeguarded, that it is hoped will lead to a system of robust, healthy, and economically self-sustaining protected areas for the country's herpetofauna. These recommendations will have to be enacted swiftly, however, due to unremitting pressure from human population growth and the resulting deforestation.**

***Resumen.*—Se discute el estatus de conservación de los miembros de la herpetofauna de Honduras. Basados en el crecimiento presente y proyectado de la población del ser humano, se propone que toda la fauna herpetológica de Honduras está en peligro de extinción. Lo que se conoce de la fauna herpetológica hondureña en el presente consiste de 334 especies, incluyendo 117 anfibios y 217 reptiles (incluyendo seis reptiles marinos, que no se discuten en este artículo). La mayoria de las especies se presentan en bajas y moderadas elevaciones en formaciones forestales de tierras bajas y/o húmedas, en las Cordilleras Septentrional y Meridional de la Serranía, y las áreas ecofisiográficas de la costa y las faldas de la montaña del Caribe. Un poco mas de un tercero de la fauna herpetológica consiste de especies endémicas o sino de esas especies restringidas al Mesoamérica Nuclear. Honduras es una área severemente afectada por la disminución de las poblaciones de anfibios, con cerca de la mitad de la fauna anfibia amenazada, en peligro, o extinta. Las principales amenazas a la sobreviviencia de los miembros de la fauna herpetológica son el crec-**

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imiento sin control de la población humana y sus vástagos, la alteración y destructión de habitación, polución, el control de pestes y predadores, el exceso de caza y explotación. Ningun anfibio o reptil hondureño está totalmente libre de el impacto humano. Se ha desarrollado una regla de medir para estimar la vulnerabilidad ambiental de las especies de anfibios, usando medidas de extensión del rango geografíco, amplitud de distribución ecológica, y estado de especialización del modo de reproducción. Se ha desarrollado una medida similar para los reptiles, usando las dos primeras medidas de vulnerabilidad usados con los anfibios, y una tercera medida para el grado de persecusión humana. Basados en estas medidas, los anfibios y reptiles muestran un rango actual de una marca de vulnerabilidad medioambiental (EVS) casi tan amplia como el rango teorético. Basados en la EVS, ambas especies de anfibios y reptiles están divididas en tres categorías, de baja, media, y alta vulnerabilidad. Hay 24 especies de anfibios y 47 de reptiles de baja vulnerabilidad, 43 especies de anfibios y 111 de reptiles de media vulnerabilidad, y 50 especies de anfibios y 53 de reptiles de alta vulnerabilidad. Teoréticamente, los valores de EVS son determinados de acuerdo de información disponible del estado presente de las taxas endémicas de Mesoamérica Nuclear. Casi la mitad (48.8%) de las especies endémicas de anfibios hondureños están ya extintos o tienen poblaciones en disminución. Poblaciones de 40.0% de las especies de anfibios de Mesoamérica Nuclear están extintas o en disminución. Un poco menos de un tercio (27.0%) de los reptiles endémicos se piensa que tienen poblaciones en disminución. Casi seis de cada diez (54.5%) de las especies de reptiles de Mesoamérica Nuclear se piensa que tienen poblaciones en disminución. Los valores de EVS proporcionan un indicador utíl del riesgo potencial, el cual muestra que las especies cuyas poblaciones actuales están disminuyendo, o son extintos o extirpados tienen EVS relativamente altos. Todas las especies con un EVS alto necesitan ser observadas de cerca para anotar los cambios en el estado de las poblaciones. Ofrecemos un grupo de recomendaciones, asumiendo que las reservas bióticas de Honduras pueden ser preservadas, se espera que esto resulte en un sistema de áreas protegidas que es robusta, saludable, y sostenible economicamente para la fauna herpetológica del país. Estas recomendaciones tienen que ser observados rapidamente, debido a la presión continua causada por el crecimiento de la población humana y la resultante destrucción de los bosques.

Key words. *Conservation status, amphibians, reptiles, herpetofauna, Honduras, distribution*

"To the extent that we depend on prosthetic devices to keep ourselves and the biosphere alive, we will render everything fragile. To the extent that we banish the rest of life, we will impoverish our own species for all time. And if we should surrender our genetic nature to machine-aided ratiocination, and our ethics and art and our very meaning to a habit of careless discursion in the name of progress, imagining ourselves godlike and absolved from our ancient heritage, we will become nothing."

E. O. Wilson
***Consilience: the unity of knowledge*, 1998**

Introduction

The portion of the closing paragraph of E. O. Wilson's (1998) powerful book quoted above provides an extremely serious warning to our species, a warning that in continuing with our plan to place all the natural world in service to ourselves, we risk erasing any meaning for our continued existence. This concept is antipodal to the usual thinking that we encounter our raison d'être as we continue to subjugate Nature to our own designs. One of the central goals of conservation biology, then, is to attempt to bridge the gap between these antithetical worldviews in an effort to salvage and restore as much of the remaining global biodiversity as possible in the shortest time possible.

It is common knowledge among biologists that the greatest amount of biodiversity resides in the area between the Tropics of Cancer and Capricorn—the tropics. It is frequently stated that 40-80% of the diversity of life occurs in this region (Miller 2001; Raven and Berg 2001). Unfortunately, this region also is subject to the highest rates of human population growth. For example, in the Western Hemisphere, there are thirty-one countries that lie wholly within the tropics. The average natural increase for these thirty-one countries is 1.71% (data obtained from the 2000 World Population Data Sheet of the Population Reference Bureau, an insert in Raven and Berg 2001). This translates to an average doubling time of 40.9 years (using the formula DT = 70/natural increase).

The countries of Central America, however, are the fastest growing ones in the American tropics (data obtained from the 2000 World Population Data Sheet of the Population Reference Bureau, an insert in Raven and Berg 2001). Natural increase ranges from a low of 1.7 in Panama to a high of 3.0 in Nicaragua, with doubling times ranging from 23 years for Nicaragua to 41 years for Panama.

Growth rates, however, are significantly higher for the nations of northern Central America than are those for lower Central America. Costa Rica and Panama have growth rates of 1.8 and 1.7, respectively, whereas those for Belize, Guatemala, El Salvador, Honduras, and Nicaragua range from 2.4 to 3.0. For the latter five countries, these figures translate to doubling times ranging from 23 (Nicaragua) to 29 years (El Salvador). The natural increase of Honduras, at 2.8%, is the third highest in Central America, being exceeded only by those of Guatemala (2.9%) and Nicaragua (3.0%). Thus, its doubling time is the third fastest in the region, at 25 years.

The senior author has been working on the herpetofauna of Honduras since 1967. In the 35 years since then, the human population of the country has grown from about 2.4 million to a figure somewhat in excess of 6.7 million (the former figure

is from Golenpaul, 1968, and the latter one is from data obtained from the 2001 World Population Data Sheet of the Population Reference Bureau, an insert in later copies of Raven and Berg 2001). In other words, in that 35-year period of time, the population of Honduras has doubled and increased by almost half again as much.

Habitat degradation and destruction are recognized as the major threats to biodiversity today (Raven and Berg 2001). Such degradation and destruction in Honduras is primarily fueled by deforestation (E. Wilson and Perlman 2000), occasioned by shifting agricultural practices, ranching, logging, and fuel gathering. The deforestation models in E. Wilson and Perlman (2000) indicate that the amount of forest remaining in 1995 amounted to 4.1 million hectares. Honduras, however, contains 43,277 sq. mi. or 11,208,935 hectares. Thus, in 1995 only about 37% of the original forested area of the country (i.e., once the entire country) remained. The E. Wilson and Perlman (2000) deforestation model for Honduras also indicates that the time to halve the remaining forest is 30.1 years. Thus, the 1995 figure of 4.1 million hectares will be down to 2.05 million hectares by about 2025. The deforestation rate indicated by E. Wilson and Perlman (2000) is -2.3% and will reduce the remaining forest in the country to 0.5 million hectares by the year 2085. It can be expected that, if these rates continue, no forest will remain in Honduras by the end of the present century.

Measured against this backdrop, it is abundantly clear that the Honduran herpetofauna, and indeed the entire biota, is endangered, in the best sense of the term. Equally clear, thus, is the rationale for an examination of the conservation status of the herpetofauna of the country. If we do not examine it now, we can only look to further deforestation, fueled by the uncontrolled growth of the human population, and increasing threats to the survival of the herpetofauna. We have no idea what the herpetofauna of Honduras looked like at the time of Columbus' arrival at Cabo de Honduras, opposite Trujillo, in 1502, but at least we do know that the known herpetofauna that existed when the senior author began to work in the country in 1967 is not the herpetofauna known today (see below).

It is the purpose of this paper to assess the conservation status of the known members of the Honduran herpetofauna and to construct a set of conservation and research priorities for the foreseeable future. It is hoped that the brutal honesty with which we have approached this work will act to spur the necessary steps to enable these priorities before this segment of the Honduran patrimony is lost for all time.

Status of our knowledge of the Honduran herpetofauna

The modern history of the study of the amphibians and reptiles of Honduras began with the first trip to the country made by John R. Meyer in 1963. Meyer was "in country" for three months with a field crew from Texas A&M University led by the mammalogist Gerald V. Mankins. It was during this trip that Meyer began to formulate an idea for a dissertation topic dealing with a survey of the herpetofauna of Honduras. With his transfer to the University of Southern California under the mentorship of Jay M. Savage, the idea became a reality.

At about the same time, Larry D. Wilson was also working on his dissertation at Louisiana State University in Baton Rouge. Unaware of Meyer's dissertation work, Wilson began to survey various collections around the country to see what material from Honduras existed there. The word got around to Meyer, who then began to correspond with Wilson. In time, Meyer suggested that Wilson join him on a three-month field trip to the country during the summer of 1967. A second three-month journey ensued in the summer of 1968.

At this point, Meyer began to write his dissertation, which was completed in 1969 (Meyer 1969). The known herpetofauna as of that publication consisted of 196 species. Two years later, Meyer and Wilson (1971) provided a checklist of the amphibian fauna containing 52 species and in 1973 a checklist of the turtle, crocodilian, and lizard fauna listing 59 species (not 58, as stated in their abstract and introduction). Wilson and Meyer (1985) treated 95 species of snakes then known to occur in Honduras (Wilson and Meyer 1982, had treated 91 species of snakes in Honduras).

In 1976, Wilson began to work with James R. McCranie, and their first paper together (joined by Louis Porras) on Honduras appeared in 1978 (Wilson et al. 1978). These same three authors described in 1980 the first new species to result from the fieldwork up to that point (McCranie et al. 1980). In 1983, Wilson produced the first list of amphibians and reptiles for the country since the work of Meyer and Wilson (1971, 1973) and Wilson and Meyer (1982). That list consisted of 208 species (56 amphibians and 152 reptiles). Wilson and McCranie (1994) produced a second update of the Honduran herpetofauna, listing a total of 277 species (89 amphibians and 188 reptiles).

The latest accounting of the species of amphibians is in McCranie and Wilson (2002). This book lists 117 species for Honduras, including two species of caecilians, 25 species of salamanders, and 90 species of anurans (one of which is reported in an addendum). The most recent list of the reptiles is in Wilson and McCranie (2002), in which are included 217 species (14 turtles, two crocodilians, 88 lizards, and 113 snakes). The total known herpetofauna, thus, as of these two publications, consists of 334 species (including six marine reptiles).

McCranie and Wilson (2002) hypothesized that seven additional species of amphibians probably reside in Honduras. A similar work in progress on the reptiles of Honduras (McCranie and Wilson, *in preparation*) lists 13 species of probable occurrence. At the present time, then, we know the herpetofauna consists of 334 species, and we think it may contain as many as 20 more species, apart from any new taxa that may be discovered. The above summarizes our current understanding of the composition of the Honduran herpetofauna.

Our understanding of the geographic and ecological distribution of the members of the herpetofauna of Honduras is summarized in McCranie and Wilson (2002) for the amphibians and, to a lesser extent, in Wilson et al. (2001). The latter situation is the case because Wilson et al. (2001) spent over five years in press and could not be consistently updated to the point it appeared in print. For example, Wilson et al. (2001) considered 276 species of amphibians and reptiles, but did not include five species of marine turtles, one species of marine snake, and six reptile species restricted in Honduras to the Swan Islands and the Miskito Keys. Inclusion of these 12

Plate 2 DOI: 10.1514/journal.arc.0000012.g002

Plate 3 DOI: 10.1514/journal.arc.0000012.g003

Plate 4 DOI: 10.1514/journal.arc.0000012.g004

Plate 5 DOI: 10.1514/journal.arc.0000012.g005

Plate 6 DOI: 10.1514/journal.arc.0000012.g006

Plate 7 DOI: 10.1514/journal.arc.0000012.g007

Plate captions: 2. Primary forest in Parque Nacional El Cusuco, Cortés. Photograph taken from 1820 m elevation on 13 April 1979. **3**. Primary forest along Río de Cusuco, Parque Nacional El Cusuco, Cortés. Photograph taken at 1670 m elevation on 13 April 1979. **4**. Primary forest in Parque Nacional de Celaque, Lempira. Photograph taken from 2440 m elevation on 28 April 1982. **5**. Primary forest along Río Seco, Parque Nacional Sierra de Agalta, Olancho. Photograph taken at 990 m elevation on 8 August 1986. Primary forest like that shown in Plates 1-4 exists today only within the boundaries of some of the biological reserves of Honduras. **6**. Primary forest along Quebrada de Oro, Parque Nacional Pico Bonito, Atlántida. Photograph taken at 950 m elevation on 4 June 1980. **7**. Quebrada de Oro, Parque Nacional Pico Bonito, Atlántida, showing destruction caused by a large landslide in November 1988. Photograph taken at 940 m elevation on 7 August 1989.

Plate 8 DOI: 10.1514/journal.arc.0000012.g008

Plate 9 DOI: 10.1514/journal.arc.0000012.g009

Plate 10 DOI: 10.1514/journal.arc.0000012.g010

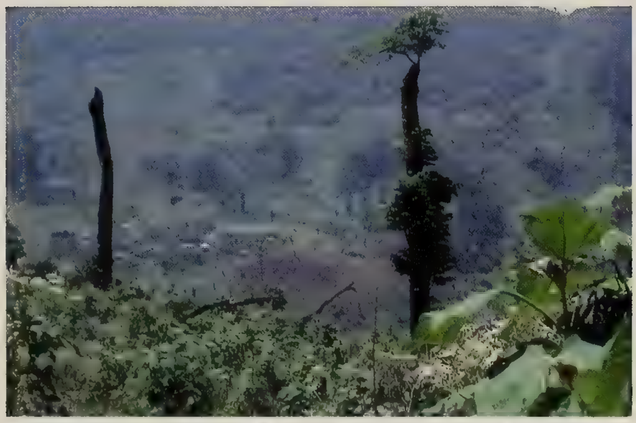

Plate 11 DOI: 10.1514/journal.arc.0000012.g011

Plate captions: 8. Collapsed ridge on slope N of Quebrada de Oro, Parque Nacional Pico Bonito, Atlántida. This ridge is part of the two large landslides that severely damaged a large portion of the Quebrada de Oro in November 1988 and November 1995. Photograph taken at ca. 1000 m elevation on 28 May 1996. **9**. Quebrada de Oro, Parque Nacional Pico Bonito, Atlántida. Portion of stream through primary forest that disappeared underground between 28 May and 2 June 1996. Colonies of army ants had invaded the dry stream bed to feed on the perished tadpoles (mostly *Atelophryniscus chrysophorus* and *Ptychohyla spinipollex*) and invertebrate carcasses. Photograph taken at 960 m elevation on 3 June 1996. **10**. El Portillo de Ocotepeque, Ocotepeque. This area was "protected" as part of the Reserva Biológica Güisayote in 1987, even though the vast majority of this reserve was already deforested at that time. Photograph taken at 1900 m elevation on 14 April 1978. **11**. Quebrada Grande, Parque Nacional Cerro Azul, Copán. The haze in the photograph is smoke from slash and burn agriculture. The only forest remaining today in this national park is on some of the steep slopes above this village. The national park was created in 1987 and the photograph was taken on 6 May 1988 (from 1500 m elevation).

species would have raised their tally to 288 species, which is 46 species fewer than the number now known to occur in the country. Thus, the information presented below is somewhat more accurate for the amphibians than it is for the reptiles, although the major distributional patterns discussed are not affected much by the relative lack of currency of the information for the reptiles, nor will it have much affect on the conclusions reached in the remainder of this paper.

Both Wilson et al. (2001) and McCranie and Wilson (2002) discussed ecological distribution of Honduran amphibians and reptiles with respect to ecological formations, physiographic regions, elevation, and ecophysiographic areas. They also discussed the broad patterns of geographic distribution of these animals.

With regard to distribution in ecological formations (modified from those of Holdridge 1967), Wilson et al. (2001) indicated that the greatest number of species occur in lowland formations (Lowland Moist Forest, Lowland Dry Forest, and Lowland Arid Forest formations) and mesic formations (Lowland Moist Forest, Premontane Wet Forest, Lower Montane Wet Forest, and Lower Montane Moist Forest formations). For the amphibians alone, however, the greatest numbers of species are found in only three of the four mesic formations (Premontane Wet Forest, Lowland Moist Forest, and Lower Montane Wet Forest formations).

With reference to distribution in physiographic regions, Wilson et al. (2001) noted that the greatest numbers of species are found in the Northern Cordillera and the Southern Cordillera, these two areas comprising the *Serranía* of Honduras. The same pattern was discovered for the amphibians when considered alone (McCranie and Wilson 2002).

Analysis of distribution with respect to elevation indicates that the greatest number of amphibians and reptiles occur at low elevations (0-600 m), although moderate elevations (601-1500 m) harbor almost as many (Wilson et al. 2001). When amphibians are considered alone, however, there is a significantly greater number of species known from moderate elevations (88 species) than from low elevations (65 species). In addition, a sizable number of species (56) also occurs at intermediate elevations (1501-2700 m).

Combining ecological formations and physiographic regions gives rise to ecophysiographic areas (see Wilson et al. 2001 for a discussion). Thirty-eight such areas were recognized by Wilson et al. (2001), of which 28 were subjected to analysis. McCranie and Wilson (2002), however, presented data on amphibian distribution in 32 of the 38 areas (see McCranie and Wilson 2002 for a map showing the distribution of these areas). Wilson et al. (2001) showed that the highest numbers of species occurred (in decreasing order) in the Eastern Caribbean Lowlands, the West-central Caribbean Lowlands, the Sula Valley, and the Central Caribbean Slope, all of which are Caribbean lowland regions or the foothills above such areas. When the amphibians are considered alone, however, a slightly different pattern emerges. The highest numbers of species of amphibians are found in the Eastern Caribbean Lowlands, the Eastern Caribbean Slope, the Central Caribbean Slope, and the Western Caribbean Slope. The prevalence of foothill regions in this list is reflective of the sizable presence of amphibians at moderate elevations in the country (see above).

Analysis of the broad patterns of geographic distribution by Wilson et al. (2001) showed that the largest numbers of species are endemic to the country or otherwise restricted to Nuclear Middle America (about a third of the herpetofauna therein considered). Slightly more than 90 percent of the herpetofauna were distributed in the area from Mexico to South America. The amphibians, when considered alone (McCranie and Wilson 2002), show the same pattern, with 56.9% either endemic to Honduras or to Nuclear Middle America and 94.0% distributed in the area from Mexico to South America.

The overall outcome of the research on the Honduran herpetofauna that has taken place since 1967 is the description of a large number of new taxa, the discovery of a sizable number of species new to the herpetofauna, and a few resurrections of formerly synonymized taxa. More recently, however, we have entered a new era in our studies in Honduras, as detailed by McCranie and Wilson (*in press*) for the amphibians. As noted above, McCranie and Wilson (2002) treated 116 species of amphibians (and another one in an addendum). The majority of these 116 amphibian species are either endemic to Honduras (41 species) or otherwise endemic to Nuclear Middle America (25 species). Thus, 56.9% of the amphibian fauna falls into these two distributional categories, as noted above. The analysis presented by McCranie and Wilson (*in press*) indicates that of the 41 endemics, six apparently have already disappeared. The populations of an additional 14 are in apparent decline (field work in 2001 indicated that one of the 14 species thought to be in decline by McCranie and Wilson, in press, has also disappeared) and there are four species for which we do not currently know the population status. Thus, only 17 of 41 species (41.5%) appear to have stable populations at the present time. Of the 25 species otherwise restricted to Nuclear Middle America, the populations of nine species appear to be in decline and those of one species appears to have been extirpated in Honduras. We have no data on the populations of an additional four species. Thus, only 11 of 25 species (44.0%) appear to have populations that are stable at this time. Of the 50 remaining amphibian species not discussed above, McCranie and Wilson (*in press*) determined that 25 (50.0%) of them require relatively undisturbed forest regions to survive, and, thus, have lost much of their habitat in recent years. In summary, the populations of only 53 of 116 species of Honduran amphibians (45.7%) appear to be stable or nearly so. Thus, close to half the known amphibian fauna of Honduras is threatened, endangered, or now extinct. This sad picture is being repeated throughout much of Latin America (Young et al. 2001).

In a following section, we attempt to establish a set of conservation priorities for all the members of the Honduran herpetofauna, using revised environmental vulnerability scores, first developed and used by Wilson and McCranie (1992).

Threats to the survival of amphibians and reptiles of Honduras

Wilson et al. (2001:109) opined that, "The most serious of the plethora of environmental problems impacting the planet currently, perhaps, is biodiversity decline, for this is the only one that is irreversible. As species of organisms are pushed to

extinction, the information stored in their genomes is irretrievably lost. What importance such creatures have in maintaining the planet's life support systems and what more immediate or direct value that information content may have for humanity is most often extremely imperfectly known to completely unknown. Upon the extinction of the organisms, such enlightenment becomes permanently unattainable." This opinion is based on a cascade of modern research concerning the nature and extent of environmental problems, most specifically about the above-discussed problem of biodiversity decline (see, for example: Ehrlich and Ehrlich 1981, 1996; E. Wilson 1984, 1988 [ed.], 1992; E. Wilson and Perlman 2000; Miller 2001; Raven and Berg 2001).

The anthropogenic threats to the Earth's biota are fairly clearly identified. E. Wilson and Perlman (2000), for example, identify the following threats as most important:

- Habitat loss and fragmentation
- Exotic species
- Overhunting
- Degradation of air, water, and soil
- Synergistic pressures

Raven and Berg (2001) listed the following factors as most important for U.S. plants and animals:

- Habitat loss and degradation
- Exotic species
- Pollution
- Overexploitation

McCranie and Wilson (2002) identified habitat alteration and destruction, pollution, and pest and predator control as the threats of greatest importance to Honduran amphibians. When one considers the reptile segment of the herpetofauna, then overhunting and overexploitation must be added to the list. However, it may be shown that the synergistic interactions of these various threats will represent the ultimate threat (E. Wilson and Perlman 2000), pushing the existing natural systems in Honduras beyond any hope of recovery. Given the rate at which habitat alteration and destruction is proceeding, as especially measured by the rate of deforestation (see the Introduction), it may be hypothesized that the collapse of most to all of the populations of the country's amphibians and reptiles will be complete at or before the end of the present century. In the same period of time, based on Honduras's human population doubling time of 25 years (data obtained from the 2000 World Population Data Sheet of the Population Reference Bureau, an insert in Raven and Berg 2001), its population will increase theoretically by a factor of 16 times! One of the most basic questions facing the populace of Honduras is what the country will be doing with its 107.2 million people it is scheduled to have by the year 2101.

In recent years, additional threats have been manifested. One such threat comes in the form of a chytrid fungus that has been implicated as a proximate cause of mortality for anurans in Australia, Costa Rica, and Panama (see Berger et al. 1998, Lips 1999). This effect is especially startling, inasmuch as it has been occurring "... in pristine areas at moderate to intermediate elevations" (McCranie and Wilson 2002, p. 539). Many tadpoles of several Honduran species of montane hylids of the genus *Plectrohyla*, as well as a species of *Ptychohyla*, have been found to have deformed keratinized mouthparts, likely a symptom of infection by a chytrid fungus (McCranie and Wilson 2002; also see Fellers et al. 2001). Another threat may be connected to "documented climatic changes associated with recent warming" (McCranie and Wilson 2002, p. 527-528), strongly implicated by Pounds et al. (1999) to be responsible for amphibian population crashes in a Costa Rican montane habitat. We suspect "these same climatic changes are also likely taking place in montane habitats within Honduras" (McCranie and Wilson 2002, p. 528) and may be implicated in what is looking like a general trend in the decline or disappearance of several anuran species in pristine regions at moderate to intermediate elevations (essentially above 900 m; see McCranie and Wilson 2002 for a more extended discussion).

What is especially frightening about these recent developments involving pathogens and climatic change is that they produce unanticipated changes that make it difficult to impossible to predict their effects. As such, it becomes difficult to impossible to *plan* for these effects. They appear to have the potential to become an environmental "super-problem," in the sense of Bright (2000). Bright (2000) uses this term to describe environmental synergisms resulting from the interaction of two or more environmental problems, so that their combined effect is greater than the sum of their individual effects. These problems represent an environmental worst-case scenario—the point when environmental problems become so serious that they produce unanticipated results, the successful resolution of which threaten to slip forever from the grasp of humanity. It is against this terrifying backdrop that we proceed with the effort to assign conservation priorities for the members of the herpetofauna of Honduras. It may be stated without fear of contradiction that there are no populations of Honduran amphibians and reptiles that are entirely free of anthropogenic impact (Wilson et al. 2001, McCranie and Wilson 2002, McCranie and Wilson, *in press*).

Establishment of conservation priorities for the Honduran herpetofauna

Prior attempts have been made by us to assess the effectiveness of the current system of biotic reserves in Honduras in protecting the country's herpetofauna (Wilson et al. 2001), to determine the status of amphibian populations (McCranie and Wilson, *in press*), and to anticipate the future of the amphibian faunal component (McCranie and Wilson 2002). Each of these efforts has pointed to significant threats to the integrity of herpetofaunal populations. In a very real sense, this is all we have been able to do—to point to these threats. Addressing these threats in any meaningful way is the responsibility of the people of Honduras—through their government, information media, educational systems, and environmental organizations. We have written this paper in the hope that looking at these problems in a different way than has been done heretofore may act to focus sufficient attention before it is too late—if it is not too late already. An overriding problem is that there is little consensus in the literature concerning the number and individual sizes of the protected areas in the country (see Table 15 in Wilson et al. 2001; Anonymous 2001).

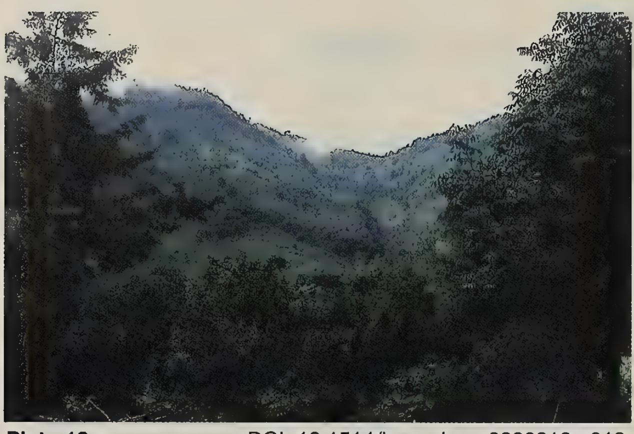

Plate 12 DOI: 10.1514/journal.arc.0000012.g012

Plate 13 DOI: 10.1514/journal.arc.0000012.g013

Plate 14 DOI: 10.1514/journal.arc.0000012.g014

Plate 15 DOI: 10.1514/journal.arc.0000012.g015

Plate 16 DOI: 10.1514/journal.arc.0000012.g016

Plate 17 DOI: 10.1514/journal.arc.0000012.g017

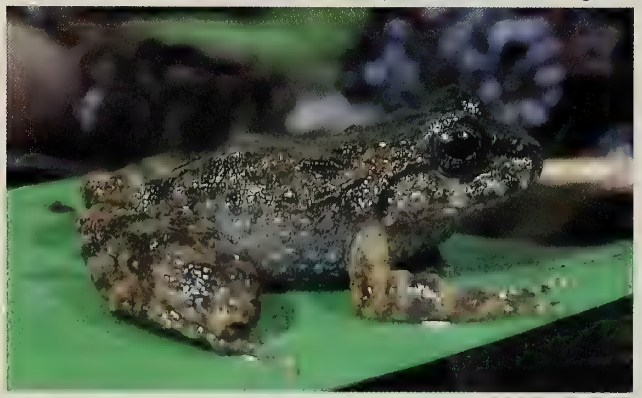

Plate 18 DOI: 10.1514/journal.arc.0000012.g018

Plate 19 DOI: 10.1514/journal.arc.0000012.g019

Plate captions: 12. Reserva Biológica El Pital, Ocotepeque. Almost no original forest remains in this reserve. Photograph taken from 1430 m elevation showing secondary gallery forest in foreground and denuded hillsides in background. 12 August 1997. **13**. Reserva de la Biósfera Río Plátano, near Quebrada de Las Marías, Olancho. The forested hillsides in the background lie about 1 km from the southern edge of the "nuclear zone" of this Biosphere Reserve. Photograph taken at 660 m elevation on 1 August 1997. We rode on horseback through this same locality in August 1998, and found the human population to have substantially increased from the previous year, as had the deforestation. **14**. 3.7 km NW of Zambrano, Francisco Morazán. Photograph taken at 1450 m elevation in June 1976. These pine forests are burned annually, thus the trees in this area are now considerably more fire scarred. In addition, tree stumps and logs lying on the ground are now largely burnt remains, offering little refuge for ground dwelling snakes. **15**. *Eleutherodactylus anciano*. **16**. *Eleutherodactylus chrysozetetes*. **17**. *Eleutherodactylus milesi*. **18**. *Eleutherodactylus stadelmani*. **Plates 15 through 18.** Honduran endemics now feared extinct. **19**. *Bolitoglossa carri*. A Honduran endemic with all known populations believed to be declining.

Many others share these concerns, of course. In fact, Honduras is one of the countries in the Western Hemisphere that figures into the Mesoamerican Biological Corridor Project ("Paseo Pantera"), as described by Illueca (1997). While expansive and desirable in concept, there are serious problems in its design and prospects in Honduras. The map of the components of this project in Mesoamerica includes a number of "protected areas" (incidentally, one of these "protected areas," the Mayan ruins of Copán, Honduras, is mismapped; what is shown apparently is the Parque Nacional Montecristo-Trifinio) and "desired green connections." We have previously discussed the pressures existing in the "protected areas" (here and in Wilson et al. 2001). Even more significantly, however, are the problems associated with attempting to turn the "desired green connections" into anything actually "green" (i.e., ecologically restored). For example, one of these connections traverses the area between the Maya Mountains Biosphere Reserve in Belize, the Copán Maya Ruins in the department of Copán in extreme western Honduras, and the Río Plátano Biosphere Reserve in northeastern Honduras. The intervening area encompasses about the western two-thirds of Honduras, in which area lives the large majority of the human population of the country. This is also the area that has suffered greatly at the hands of agriculturists for centuries, to the point that Hondurans, especially the landless poor, are moving in significant numbers to the less heavily exploited Mosquitia in eastern Honduras. Creating a "green connection" through this area of the country appears to us to be an impossibly large task.

Several years ago (Wilson and McCranie 1992), we developed an environmental vulnerability gauge for use with amphibian populations. We then (McCranie and Wilson 2002) updated it for use with the 116 species of amphibians treated in *The Amphibians of Honduras*. For this paper, we have developed a similar gauge for the reptiles. The gauge for amphibians and that for reptiles resemble one another in using scales for extent of geographic range and ecological distribution. The two gauges differ from one another in that susceptibility of reproductive mode to anthropogenic pressure is used for amphibians and extent of human persecution is used for reptiles (see below).

We use these gauges to establish a set of conservation priorities for the remaining species of the Honduran herpetofauna. This is an approach different from the one we adopted in Wilson et al. (2001), which attempted to evaluate the effectiveness of the existing system of biotic reserves to protect *all* members of the herpetofauna known at the time, and to make suggestions about where additional reserves needed to be established. In essence, we have been forced to adopt a different approach, given the mute testimony provided in recent years by disappearing Honduran amphibians.

As noted above, this environmental vulnerability gauge for both amphibians and reptiles has three components, which are described below. The first component of the gauge, applicable to both groups, deals with the extent of the geographic range using the following scale:

1 = widespread in and outside of Honduras
2 = distribution peripheral to Honduras, but widespread elsewhere
3 = distribution restricted to Nuclear Middle America (exclusive of Honduran endemics)
4 = distribution restricted to Honduras
5 = known only from the vicinity of the type locality

As is evident, in a rough sense, the degree of restriction of geographic range increases as the scale number increases.

The second gauge component, also applicable to both groups, indicates the extent of ecological distribution, based on a modified version of the forest formations of Holdridge (1967), using the following scale (omitting consideration of the Montane Rainforest formation, the herpetofauna of which is almost completely unknown):

1 = occurs in eight formations
2 = occurs in seven formations
3 = occurs in six formations
4 = occurs in five formations
5 = occurs in four formations
6 = occurs in three formations
7 = occurs in two formations
8 = occurs in one formation

The degree of restriction of ecological range increases as the scale number increases, similar to that of geographic range in the previous component.

In gauging the degree of specialization of reproductive mode in amphibians, as it relates to the effect of environmental modification, especially deforestation, we use the following scale:

1 = both eggs and tadpoles in large or small bodies of lentic or lotic water
2 = eggs in foam nests, tadpoles in small bodies of lentic or lotic water
3 = tadpoles occur in small bodies of lentic or lotic water, eggs elsewhere
4 = eggs laid in moist situations on land or moist arboreal situations, direct development
5 = eggs and tadpoles in water-retaining arboreal bromeliads or water-filled tree cavities

Again, increase in number signifies probable increase in reproductive vulnerability to the effects of habitat degradation.

In light of the fact that reptiles are amniote vertebrates and, thus, do not possess the biphasic life cycle or the range of reproductive modes typical of amphibians, it is necessary to develop another gauge of human pressure on the populations of these animals. In addition, reptiles, being vertebrates fully adapted to life on land, are often more noticeable to humans and more frequently encountered than are amphibians, especially larval amphibians. Moreover, many, if not most, reptiles are the subjects of superstition, ignorance, fear, and, as a consequence, outright killing upon sight. Finally, given that all Honduran reptiles are scaled vertebrates and some are large enough to be of commercial interest for their hides, meat, and/or eggs, these species are hunted (i.e., actively sought) for these products. Taking these biological and sociological features into consideration, we developed the following scale to indicate the degree of human persecution:

1 = fossorial, usually escape human notice
2 = semifossorial, or nocturnal arboreal or aquatic, nonvenomous and usually nonmimicking, sometimes escape human notice
3 = terrestrial and/or arboreal or aquatic, generally ignored by humans
4 = terrestrial and/or arboreal or aquatic, thought to be harmful, may be killed on sight
5 = venomous species or mimics thereof, killed on sight
6 = commercially or noncommercially exploited for hides and/or meat and/or eggs

As with the previously discussed components, the degree of threat from human beings roughly increases as the scale number increases.

In order to obtain this rough idea of environmental vulnerability, thus, each of the three applicable scores has been determined for each Honduran amphibian and reptilian species. Then the numbers associated with the three scales have been added to obtain a composite score. These composite scores can range theoretically from a low of three to a high of 18 for amphibians and from a low of three to a high of 19 for reptiles.

The composite environmental vulnerability scores (EVS; used either in singular or plural form, as determined by context) for amphibians (Table 1) actually range from a low of three to a high of 17, almost the entire gamut. The numbers of species attaining the various EVS are as follows:

EVS 3-1 species	EVS 11-12 species
EVS 4-1 species	EVS 12-13 species
EVS 5-5 species	EVS 13-13 species
EVS 6-7 species	EVS 14-15 species
EVS 7-2 species	EVS 15-17 species
EVS 8-2 species	EVS 16-10 species
EVS 9-6 species	EVS 17-8 species
EVS 10-5 species	

Using this measure, the least vulnerable amphibian species are *Bufo marinus, B. valliceps, Hyla microcephala, Phrynohyas venulosa, Scinax staufferi, Smilisca baudinii*, and *Rana berlandieri*. They are all 1-1-1, 1-2-1, or 1-3-1 species (species widespread geographically in and outside of Honduras, of broad ecological occurrence, and having the least derived reproductive mode). The most vulnerable species are *Bolitoglossa carri, B. decora, B. longissima, Nototriton lignicola, Eleutherodactylus chrysozetetes, E. coffeus, E. cruzi*, and *E. merendonensis*. They are all 5-8-4 species (species known only from the vicinity of the type locality, in one forest formation, with eggs laid in moist situations on land or moist arboreal situations). In addition, three of the four species of *Eleutherodactylus* (save for *E. coffeus* for which there are no data available) appear to have already disappeared or are in decline (McCranie and Wilson, *in press*).

We have used the same method in this paper as McCranie and Wilson (2002). Thus, we have divided the species of Honduran amphibians into three categories of environmental vulnerability, i.e., low vulnerability, of medium vulnerability, and high vulnerability. This categorization provides an initial rough means of gauging the degree of attention that ought to be focused on the various taxa. Thus, the species that can be expected to have the best chance to survive in the face of continued environmental degradation are those in the first category. These 24 species make up only 20.5% of the Honduran amphibian fauna. A larger group of 43 species, making up 36.8% belongs to the medium category; nonetheless, this is a heterogeneous grouping, created due to a lack of weighting of the three categories used to compute the EVS, in which relatively widespread species, such as *Agalychnis callidryas*, are grouped with highly restricted ones, such as *Plectrohyla chrysopleura*. A larger group of 50 high vulnerability species, making up 42.7%, can be expected to have the poorest chance for survival. Almost all of these species are endemic to Honduras or are otherwise restricted to Nuclear Middle America. Additionally, recent declines or disappearances in amphibian populations from moderate to intermediate elevation, pristine habitats were not considered in this analysis. The importance of these declines and disappearances, however, is discussed in the following section.

The composite environmental vulnerability scores (EVS) for reptiles (Table 2) actually range from a low of four to a high of 19, only one number less than the entire theoretical range (marine species not included). The numbers of species attaining the various EVS are as follows:

EVS 4 - 1 species	EVS 12 - 42 species
EVS 5 -1 species	EVS 13 - 28 species
EVS 6 -2 species	EVS 14 - 15 species
EVS 7 - 9 species	EVS 15 - 23 species
EVS 8 - 11 species	EVS 16 - 11 species
EVS 9 - 23 species	EVS 17 - 2 species
EVS 10 - 19 species	EVS 18 - 1 species
EVS 11 - 22 species	EVS 19 - 1 species

The least vulnerable reptilian species, by this measure, are *Norops tropidonotus, Enulius flavitorques, Imantodes cenchoa*, and *Ninia sebae*. They are 1-1-2, 1-1-3, or 1-3-2 species (widespread geographically, occurring in six or eight forest formations, and semifossorial or terrestrial/arboreal, sometimes escaping human notice). The most vulnerable reptile is *Ctenosaura bakeri*, 5-8-6 species (known only from the vicinity of the type locality, in one forest formation, and used for its meat and eggs locally). The next most vulnerable is *Ctenosaura oedirhina*, a 4-8-6 species (a Honduran endemic, occurring in one forest formation, and used for its meat and eggs locally).

As for the amphibians, we have divided the species of Honduran reptiles into three categories of environmental vulnerability, as indicated in Table 2. As above, this categorization is intended as a coarse gauge as to the degree of attention that should be brought to bear on the various species. There are 47 low vulnerability species, making up only 22.3% of the Honduran reptilian fauna. A slightly larger group of 53 species, making up 25.1% of the taxa, comprises the high vulnerability category. Many of these species (35) are endemic to Honduras. The largest group of 111 species, as with the amphibians, is composed of taxa of intermediate vulnerability (52.6% of total). Most of these species (93) are geographically widespread, although in many cases occurring peripherally to Honduras, and many (66) are known from only one or two forest formations.

Table 1. Environmental vulnerability scores (EVS) for the 117 species of amphibians of Honduras. Numbers for each gauge explained in text. The table is broken into three parts: low vulnerability species (EVS of 3–9; 24 species; 20.5%); medium vulnerability species (EVS of 10–13; 43 species; 36.8%); and high vulnerability species (EVS of 14–17; 50 species; 42.7%). Updated from Table 33 in McCranie and Wilson (2002).

Amphibian Species	Geographic Distribution	Ecological Distribution	Reproductive Mode	Total Score
Low				
Bolitoglossa mexicana	1	4	4	9
Bufo coccifer	1	4	1	6
Bufo luetkenii	1	5	1	7
Bufo marinus	1	3	1	5
Bufo valliceps	1	3	1	5
Hyalinobatrachium fleischmanni	1	5	3	9
Hyla loquax	1	4	1	6
Hyla microcephala	1	3	1	5
Hyla picta	1	7	1	9
Phrynohyas venulosa	1	3	1	5
Plectrohyla guatemalensis	3	5	1	9
Ptychohyla hypomykter	3	5	1	9
Scinax staufferi	1	3	1	5
Smilisca baudinii	1	2	1	4
Eleutherodactylus laevissimus	1	3	4	8
Leptodactylus labialis	1	3	2	6
Leptodactylus melanonotus	1	3	2	6
Physalaemus pustulosus	1	3	2	6
Hypopachus variolosus	1	4	1	6
Rana berlandieri	1	1	1	3
Rana forreri	1	6	1	8
Rana maculata	1	4	1	6
Rana vaillanti	1	5	1	7
Rhinophrynus dorsalis	1	7	1	9
Medium				
Dermophis mexicanus	1	7	4	12
Gymnopis multiplicata	1	7	4	12
Bolitoglossa rufescens complex	3	5	4	12
Oedipina cyclocauda	1	6	4	11
Atelophryniscus chrysophorus	4	7	1	12
Bufo campbelli	2	7	1	10
Bufo haematiticus	2	8	1	11
Bufo leucomyos	4	6	1	11
Centrolene prosoblepon	2	7	3	12
Cochranella albomaculata	2	7	3	12
Cochranella granulosa	2	7	3	12
Cochranella spinosa	2	8	3	13
Hyalinobatrachium pulveratum	2	7	3	12
Agalychnis calcarifer	2	8	3	13
Agalychnis callidryas	1	6	3	10
Agalychnis moreletii	2	8	3	13
Agalychnis saltator	2	8	3	13
Duellmanohyla salvavida	4	7	1	12
Duellmanohyla soralia	3	6	1	10
Hyla catracha	4	8	1	13
Hyla ebraccata	1	7	3	11
Plectrohyla chrysopleura	5	7	1	13
Plectrohyla dasypus	4	8	1	13
Plectrohyla exquisita	4	8	1	13
Plectrohyla hartwegi	3	8	1	12
Plectrohyla matudai	3	6	1	10
Plectrohyla psiloderma	3	8	1	12

Continued on page 18.

Table 1. Continued.

Amphibian Species	Geographic Distribution	Ecological Distribution	Reproductive Mode	Total Score
Ptychohyla salvadorensis	3	7	1	11
Ptychohyla spinipollex	4	6	1	11
Scinax boulengeri	2	8	1	11
Smilisca phaeota	2	7	1	10
Smilisca sordida	2	8	1	11
Triprion petasatus	3	8	1	12
Eleutherodactylus charadra	3	6	4	13
Eleutherodactylus fitzingeri	2	7	4	13
Eleutherodactylus mimus	2	7	4	13
Eleutherodactylus noblei	2	7	4	13
Eleutherodactylus ridens	1	7	4	12
Leptodactylus pentadactylus	2	7	2	11
Leptodactylus silvanimbus	4	7	2	13
Gastrophryne elegans	2	8	1	11
Hypopachus barberi	3	7	1	11
Rana warszewitschii	2	8	1	11
High				
Bolitoglossa carri	5	8	4	17
Bolitoglossa celaque	4	8	4	16
Bolitoglossa conanti	3	7	4	14
Bolitoglossa decora	5	8	4	17
Bolitoglossa diaphora	4	8	4	16
Bolitoglossa dofleini	3	7	4	14
Bolitoglossa dunni	3	7	4	14
Bolitoglossa longissima	5	8	4	17
Bolitoglossa occidentalis	2	8	4	14
Bolitoglossa porrasorum	4	7	4	15
Bolitoglossa striatula	2	8	4	14
Bolitoglossa synoria	3	8	4	15
Cryptotriton nasalis	4	7	4	15
Dendrotriton sanctibarbarus	4	8	4	16
Nototriton barbouri	4	7	4	15
Nototriton lignicola	5	8	4	17
Nototriton limnospectator	4	8	4	16
Oedipina elongata	3	8	4	15
Oedipina gephyra	4	8	4	16
Oedipina ignea	3	7	4	14
Oedipina stuarti	4	7	4	15
Oedipina taylori	3	8	4	15
Hyalinobatrachium cardiacalyptum	4	7	3	14
Hyalinobatrachium crybetes	5	7	3	15
Anotheca spinosa	2	8	5	15
Hyla bromeliacia	3	7	5	15
Hyla insolita	5	8	3	16
Hyla salvaje	3	8	5	16
Eleutherodactylus anciano	4	7	4	15
Eleutherodactylus aurilegulus	4	6	4	14
Eleutherodactylus chac	3	7	4	14
Eleutherodactylus chrysozetetes	5	8	4	17
Eleutherodactylus coffeus	5	8	4	17
Eleutherodactylus cruzi	5	8	4	17
Eleutherodactylus emleni	4	6	4	14
Eleutherodactylus epochthidius	4	7	4	15
Eleutherodactylus fecundus	4	7	4	15

Continued on page 20.

Plate 20 DOI: 10.1514/journal.arc.0000012.g020

Plate 21 DOI: 10.1514/journal.arc.0000012.g021

Plate 22 DOI: 10.1514/journal.arc.0000012.g022

Plate 23 DOI: 10.1514/journal.arc.0000012.g023

Plate 24 DOI: 10.1514/journal.arc.0000012.g024

Plate 25 DOI: 10.1514/journal.arc.0000012.g025

Plate 26 DOI: 10.1514/journal.arc.0000012.g026

Plate 27 DOI: 10.1514/journal.arc.0000012.g027

Plate captions: 20. *Oedipina gephyra*. **21**. *Atelophryniscus chrysophorus*. **22**. *Duellmanohyla salvavida*. **23**. *Hyla catracha*. **24**. *Plectrohyla chrysopleura*. **25**. *Eleutherodactylus epochthidius*. **26**. *Eleutherodactylus fecundus*. **27**. *Eleutherodactylus pechorum*. **Plates 20 through 27.** Honduran endemics with all known populations believed to be declining.

Table 1. Continued.

Amphibian Species	Geographic Distribution	Ecological Distribution	Reproductive Mode	Total Score
Eleutherodactylus laticeps	2	8	4	14
Eleutherodactylus lauraster	3	7	4	14
Eleutherodactylus loki	2	8	4	14
Eleutherodactylus megacephalus	2	8	4	14
Eleutherodactylus merendonensis	5	8	4	17
Eleutherodactylus milesi	4	7	4	15
Eleutherodactylus olanchano	4	8	4	16
Eleutherodactylus omoaensis	4	8	4	16
Eleutherodactylus operosus	4	7	4	15
Eleutherodactylus pechorum	4	7	4	15
Eleutherodactylus rostralis	3	7	4	14
Eleutherodactylus saltuarius	4	8	4	16
Eleutherodactylus stadelmani	4	7	4	15

DOI: 10.1514/journal.arc.0000012.t001

Categorization of EVS provides a means to assign conservation priorities, with high vulnerability species given highest priority, medium vulnerability species intermediate priority, and low vulnerability species lowest priority. The highest priority taxa include 50 amphibians and 53 reptiles (total of 103 species or 31.4% of 328 total species); the intermediate priority taxa consist of 43 amphibians and 111 reptiles (total of 154 species or 47.0%); and the low priority taxa comprise 24 amphibians and 47 reptiles (total of 71 species or 21.6%).

Current population status of members of the Honduran herpetofauna

The above discussion attempts to assign conservation priorities to the members of the Honduran herpetofauna on a largely theoretical basis, with the assumption that there are features of distribution (geographic and ecological), life history (reproductive mode), and human persecution that can act as a rough gauge of vulnerability to anthropogenic environmental pressures, in a similar manner as has been done for threatened and endangered species in general (see Raven and Berg 2001 for a discussion of such features).

As noted in a previous section, however, there are factors at work in Honduras, as elsewhere in the world, the effect of which were not predicted by the typical models of species endangerment. The unanticipated factors apparently of greatest importance are chytridiomycosis (Berger et al. 1998) and climatic warming (Pounds et al. 1999), although neither has been conclusively demonstrated to be in effect in Honduras.

Whatever the causative factors that may be involved, it is apparent that populations of many members of the Honduran herpetofauna are in decline or have disappeared since the early years of the 1990s (Wilson and McCranie 1998, McCranie and Wilson 2002, *in press*). The declines have been substantiated best among amphibian populations. Unfortunately, these declines have involved the two most important groups of amphibians, those endemic to Honduras and those otherwise restricted to Nuclear Middle America (Table 3). As noted by McCranie and Wilson (*in press*), of the 41 species of endemic amphibians, six are feared extinct and 14 appear to have declining populations (field work in 2001 indicated that one of the 14 species, *Eleutherodactylus stadelmani*, thought to be in decline by McCranie and Wilson, *in press*, has also disappeared). In addition, we have no data for four species. Only 17 species appear to have stable populations. Thus, 20 of the 41 endemic species of Honduran amphibians (48.8%), or almost half, are already gone or are in decline.

The seven endemic amphibian species feared extinct have EVS ranging between 14 and 17 (mean 15.6). The 13 species whose populations are in decline have EVS from 12 to 17 (mean 14.4). Of considerable interest is the fact that the EVS for the 17 endemics thought to have stable populations range from 11 to 17, with a mean value of 15.0. The implication of these data are that there is an urgent need to monitor populations of these supposed "stable" species, because 14 of the 17 have scores indicative of high vulnerability to environmental pressures.

McCranie and Wilson (*in press*) also discussed the population status of 25 amphibian species not endemic to Honduras, but restricted in distribution to Nuclear Middle America. They considered nine species to be in decline and one to probably have been extirpated. The EVS of the nine in decline range from nine to 16 (mean 12.1). The one species thought extirpated (*Bolitoglossa occidentalis*) has an EVS of 14. These data indicate that EVS of 13 and above are indicative of species that need to be monitored, but that scores below that level do not insulate a species from anthropogenic pressure. As we have noted above, there is no species of Honduran amphibian safe from human depredation, although there are clearly some species capable of persisting as commensals of human beings.

The picture for Honduran reptiles is somewhat less clear. This is due to the fully terrestrial life cycle of most reptiles, which allows for habitation of niches removed from water, in turn increasing the potential breadth of occurrence. Nonetheless, it is possible to comment on the current popula-

Table 2. Environmental vulnerability scores (EVS) for the 211 species of reptiles of Honduras (marine species are not included). Numbers for each gauge explained in text. The table is broken into three parts: low vulnerability species (EVS of 4–9; 47 species; 22.3%); medium vulnerability species (EVS of 10–13; 111 species; 52.6%); and high vulnerability species (EVS of 14–19; 53 species; 25.1%).

Reptilian Species	Geographic Distribution	Ecological Distribution	Human Persecution	Total Score
Low				
Rhinoclemmys pulcherrima	1	5	3	9
Kinosternon leucostomum	1	5	3	9
Kinosternon scorpioides	1	5	3	9
Sphaerodactylus millepunctatus	1	3	3	7
Basiliscus vittatus	1	3	3	7
Laemanctus longipes	1	5	3	9
Sceloporus malachiticus	1	4	3	8
Sceloporus variabilis	1	3	3	7
Norops cupreus	1	5	3	9
Norops laeviventris	1	5	3	9
Norops lemurinus	1	5	3	9
Norops sericeus	1	3	3	7
Norops tropidonotus	1	1	3	5
Mabuya unimarginata	1	3	3	7
Sphenomorphus cherriei	1	3	3	7
Gymnophthalmus speciosus	1	4	3	8
Ameiva undulata	1	3	3	7
Cnemidophorus deppii	1	4	3	8
Cnemidophorus motaguae	1	5	3	9
Leptotyphlops goudotii	1	5	1	7
Boa constrictor	1	3	4	8
Adelphicos quadrivirgatus	1	5	2	8
Coniophanes fissidens	1	4	4	9
Conophis lineatus	1	4	4	9
Dryadophis melanolomus	1	4	4	9
Drymarchon melanurus	1	4	4	9
Drymobius margaritiferus	1	2	4	7
Enulius flavitorques	1	3	2	6
Hydromorphus concolor	1	6	2	9
Imantodes cenchoa	1	3	2	6
Lampropeltis triangulum	1	3	5	9
Leptodeira annulata	1	3	4	8
Leptodeira septentrionalis	1	4	4	9
Leptophis ahaetulla	1	3	4	8
Leptophis mexicanus	1	3	4	8
Ninia diademata	1	5	2	8
Ninia sebae	1	1	2	4
Oxybelis aeneus	1	4	4	9
Rhadinaea godmani	1	6	2	9
Sibon nebulatus	1	5	2	8
Spilotes pullatus	1	4	4	9
Storeria dekayi	1	6	2	9
Tantilla melanocephala	1	6	2	9
Thamnophis proximus	1	4	4	9
Tretanorhinus nigroluteus	1	5	2	8
Micrurus nigrocinctus	1	3	5	9
Porthidium ophryomegas	1	3	5	9
Medium				
Crocodylus acutus	1	6	6	13
Chelydra serpentina	1	6	6	13
Rhinoclemmys annulata	2	8	3	13
Rhinoclemmys areolata	2	7	3	12

Continued on page 24.

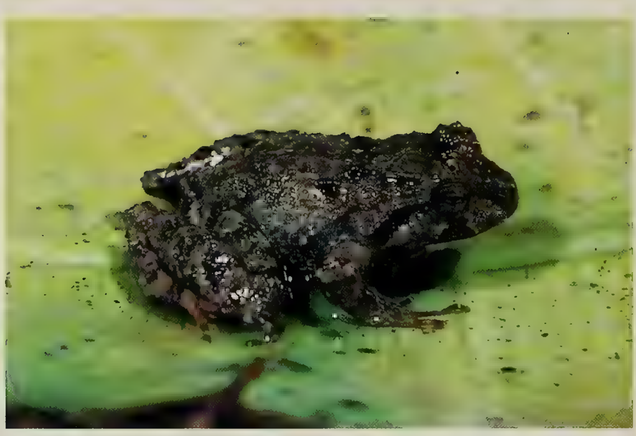

Plate 28 DOI: 10.1514/journal.arc.0000012.g028

Plate 29 DOI: 10.1514/journal.arc.0000012.g029

Plate 30 DOI: 10.1514/journal.arc.0000012.g030

Plate 31 DOI: 10.1514/journal.arc.0000012.g031

Plate 32 DOI: 10.1514/journal.arc.0000012.g032

Plate 33 DOI: 10.1514/journal.arc.0000012.g033

Plate 34 DOI: 10.1514/journal.arc.0000012.g034

Plate 35 DOI: 10.1514/journal.arc.0000012.g035

Plate captions: **28**. *Eleutherodactylus saltuarius*. **29**. *Leptodactylus silvanimbus*. **30**. *Abronia salvadorensis*. **31**. *Norops kreutzi*. **32.** *Norops muralla*. **33**. *Norops ocelloscapularis*. **34**. *Norops wampuensis*. **35**. *Typhlops stadelmani*. **Plates 28 through 35.** Honduran endemics with all known populations believed to be declining.

Plate 36 DOI: 10.1514/journal.arc.0000012.g036

Plate 37 DOI: 10.1514/journal.arc.0000012.g037

Plate 38 DOI: 10.1514/journal.arc.0000012.g038

Plate 39 DOI: 10.1514/journal.arc.0000012.g039

Plate 40 DOI: 10.1514/journal.arc.0000012.g040

Plate 41 DOI: 10.1514/journal.arc.0000012.g041

Plate 42 DOI: 10.1514/journal.arc.0000012.g042

Plate 43 DOI: 10.1514/journal.arc.0000012.g043

Plate captions: 36. *Enulius bifoveatus*. **37**. *Tantilla tritaeniata*. **38**. *Bothriechis marchi*. **39**. *Bolitoglossa dofleini*. **40**. *Bolitoglossa synoria*. **41**. *Duellmanohyla soralia*. **42**. *Plectrohyla guatemalensis*. **43**. *Plectrohyla matudai*. **Plates 36 through 38.** Honduran endemics with all known populations believed to be declining. **Plates 39 through 43.** Nuclear Middle American Restricted Species with all known Honduran populations believed to be declining.

Table 2. Continued.

Reptilian Species	Geographic Distribution	Ecological Distribution	Human Persecution	Total Score
Trachemys scripta	1	5	6	12
Celestus bivittatus	3	7	3	13
Mesaspis moreletii	3	7	3	13
Coleonyx mitratus	1	5	4	10
Aristelliger georgeensis	2	8	3	13
Aristelliger praesignis	2	8	3	13
Gonatodes albogularis	1	6	3	10
Hemidactylus brookii	2	8	3	13
Hemidactylus frenatus	2	6	3	11
Hemidactylus mabouia	2	8	3	13
Phyllodactylus tuberculosus	1	6	3	10
Sphaerodactylus glaucus	2	8	3	13
Sphaerodactylus notatus	2	8	3	13
Thecadactylus rapicauda	1	5	4	10
Basiliscus plumifrons	2	8	3	13
Corytophanes cristatus	1	7	3	11
Corytophanes hernandesii	2	7	3	12
Laemanctus serratus[1]	2	7	3	12
Ctenosaura flavidorsalis	3	7	3	13
Ctenosaura similis	1	4	6	11
Iguana iguana	1	5	6	12
Leiocephalus carinatus	2	8	3	13
Sceloporus squamosus	1	6	3	10
Anolis allisoni	2	8	3	13
Norops biporcatus	1	6	3	10
Norops capito	1	7	3	11
Norops crassulus	3	7	3	13
Norops humilis	2	7	3	12
Norops limifrons	2	7	3	12
Norops lionotus	2	8	3	13
Norops pentaprion	1	7	3	11
Norops petersii	2	8	3	13
Norops rodriguezii	2	5	3	10
Norops sagrei	2	8	3	13
Norops uniformis	2	6	3	11
Polychrus gutturosus	1	8	3	12
Eumeces sumichrasti	1	7	3	11
Mesoscincus managuae	2	7	3	12
Sphenomorphus assatus	2	8	3	13
Sphenomorphus incertus	2	7	3	12
Ameiva ameiva[2]	2	8	3	13
Ameiva festiva	1	6	3	10
Cnemidophorus lemniscatus	1	8	3	12
Lepidophyma flavimaculatum	1	6	4	11
Typhlops costaricensis	2	8	1	11
Typhlops stadelmani	4	7	1	12
Loxocemus bicolor	1	6	4	11
Corallus annulatus	1	8	2	11
Ungaliophis continentalis	3	7	2	12
Alsophis cantherigerus	2	8	3	13
Amastridium veliferum	2	8	2	12
Chironius grandisquamis	1	7	4	12
Clelia clelia	1	6	4	11
Coniophanes bipunctatus	1	6	4	11
Coniophanes imperialis	1	6	4	11

Continued on page 25.

Table 2. Continued.

Reptilian Species	Geographic Distribution	Ecological Distribution	Human Persecution	Total Score
Coniophanes piceivittis	1	6	4	11
Dendrophidion nuchale	1	7	4	12
Dendrophidion percarinatum	1	7	4	12
Dipsas bicolor	2	7	2	11
Dryadophis dorsalis	3	5	4	12
Drymobius chloroticus	1	6	4	11
Elaphe flavirufa	1	7	4	12
Erythrolamprus mimus	1	6	5	12
Ficimia publia	1	7	3	11
Geophis fulvoguttatus	3	7	2	12
Geophis hoffmanni	2	8	2	12
Imantodes gemmistratus	1	7	2	10
Imantodes inornatus	1	7	2	10
Leptodeira nigrofasciata	1	5	4	10
Leptodrymus pulcherrimus	1	5	4	10
Masticophis mentovarius	1	6	4	11
Ninia espinali	3	7	2	12
Ninia maculata	2	8	2	12
Nothopsis rugosus	2	8	2	12
Oxybelis brevirostris	2	7	4	13
Oxybelis fulgidus	1	5	4	10
Oxyrhopus petola	1	7	5	13
Pliocercus elapoides	1	4	5	10
Pseustes poecilonotus	1	7	4	12
Rhadinaea kinkelini	3	7	2	12
Rhadinaea lachrymans	3	8	2	13
Rhadinaea montecristi	3	7	2	12
Scaphiodontophis annulatus	1	6	5	12
Senticolis triaspis	1	5	4	10
Sibon carri	3	7	2	12
Sibon dimidiatus	1	6	4	11
Sibon longifrenis	2	7	2	11
Stenorrhina degenhardtii	1	5	4	10
Stenorrhina freminvillei	1	6	4	11
Tantilla impensa	3	7	2	12
Tantilla lempira	4	7	2	13
Tantilla schistosa	1	7	2	10
Tantilla taeniata	3	5	2	10
Tantillita lintoni	3	8	2	13
Thamnophis marcianus	1	8	4	13
Trimorphodon biscutatus	1	5	4	10
Tropidodipsas fischeri	3	7	2	12
Tropidodipsas sartorii	1	6	5	12
Urotheca guentheri	2	8	2	12
Xenodon rabdocephalus	1	6	5	12
Micrurus diastema	2	5	5	12
Atropoides nummifer	1	6	5	12
Bothriechis schlegelii	1	6	5	12
Bothrops asper	1	6	5	12
Cerrophidion godmani	1	6	5	12
Crotalus durissus	1	6	5	12
Porthidium nasutum	1	6	5	12
High				
Caiman crocodilus	2	8	6	16

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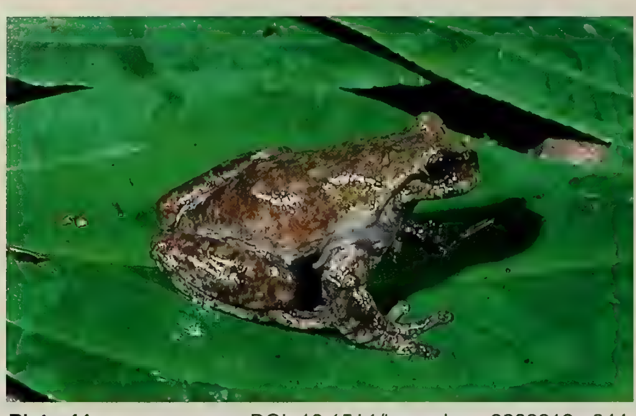

Plate 44 DOI: 10.1514/journal.arc.0000012.g044

Plate 45 DOI: 10.1514/journal.arc.0000012.g045

Plate 46 DOI: 10.1514/journal.arc.0000012.g046

Plate 47 DOI: 10.1514/journal.arc.0000012.g047

Plate 48 DOI: 10.1514/journal.arc.0000012.g048

Plate 49 DOI: 10.1514/journal.arc.0000012.g049

Plate 50 DOI: 10.1514/journal.arc.0000012.g050

Plate captions: 44. *Plectrohyla psiloderma*. **45**. *Ptychohyla hypomykter*. **46**. *Abronia montecristoi*. **47**. *Celestus bivittatus*. **48**. *Corytophanes percarinatus*. **49**. *Tropidodipsas fischeri*. **50**. *Bothriechis thalassinus*. **Plates 44 through 50.** Nuclear Middle American Restricted Species with all known Honduran populations believed to be declining.

Table 2. Continued.

Reptilian Species	Geographic Distribution	Ecological Distribution	Human Persecution	Total Score
Rhinoclemmys funerea	2	8	6	16
Staurotypus triporcatus	2	7	6	15
Abronia montecristoi	3	8	4	15
Abronia salvadorensis	4	8	4	16
Celestus montanus	4	7	3	14
Celestus scansorius	4	7	3	14
Phyllodactylus palmeus	4	8	3	15
Sphaerodactylus dunni	4	7	3	14
Sphaerodactylus rosaurae	4	8	3	15
Corytophanes percarinatus	3	8	3	14
Ctenosaura bakeri	5	8	6	19
Ctenosaura melanosterna	4	7	6	17
Ctenosaura oedirhina	4	8	6	18
Norops amplisquamosus	5	8	3	16
Norops bicaorum	5	8	3	16
Norops cusuco	5	8	3	16
Norops heteropholidotus	3	8	3	14
Norops johnmeyeri	4	8	3	15
Norops kreutzi	5	8	3	16
Norops loveridgei	4	7	3	14
Norops muralla	4	8	3	15
Norops ocelloscapularis	5	7	3	15
Norops pijolensis	4	7	3	14
Norops purpurgularis	4	8	3	15
Norops roatanensis	4	8	3	15
Norops rubribarbaris	5	8	3	16
Norops sminthus	4	8	3	15
Norops utilensis	5	8	3	16
Norops wampuensis	5	8	3	16
Norops yoroensis	4	7	3	14
Norops zeus	4	7	3	14
Crisantophis nevermanni	2	8	4	14
Drymobius melanotropis	2	8	4	14
Enulius bifoveatus	5	8	2	15
Enulius roatanensis	5	8	2	15
Geophis damiani	5	8	2	15
Leptophis modestus	3	8	4	15
Leptophis nebulosus	2	8	4	14
Omoadiphas aurula	5	8	2	15
Oxybelis wilsoni	4	8	3	15
Rhadinaea tolpanorum	5	8	2	15
Rhinobothryum bovallii	2	8	5	15
Scolecophis atrocinctus	2	7	5	14
Sibon anthracops	1	8	5	14
Tantilla tritaeniata	5	8	2	15
Thamnophis fulvus	3	7	4	14
Micrurus alleni	2	8	5	15
Micrurus browni	2	8	5	15
Micrurus ruatanus	4	8	5	17
Agkistrodon bilineatus	2	8	5	15
Bothriechis marchi	4	7	5	16
Bothriechis thalassinus	3	7	5	15

[1] Based on specimens without precise locality data and one sight record in the Middle Choluteca Valley.
[2] However, this species is extirpated on the Swan Islands, the only place where this species is known in Honduras.
DOI: 10.1514/journal.arc.0000012.t002

Table 3. Current status of populations of Honduran amphibian endemics and species otherwise restricted to Nuclear Middle America. Stable = at least some populations stable; Declining = all populations believed to be declining. Extinct category applies to Honduran endemics; extirpated category applies to Nuclear Middle American endemics (excluding those endemic to Honduras).

Species	Stable	Declining	Extinct or Extirpated	No Data
Honduran endemics				
Bolitoglossa carri		X		
Bolitoglossa celaque	X			
Bolitoglossa decora	X			
Bolitoglossa diaphora	X			
Bolitoglossa longissima	X			
Bolitoglossa porrasorum	X			
Cryptotriton nasalis	X			
Dendrotriton sanctibarbarus	X			
Nototriton barbouri	X			
Nototriton lignicola	X			
Nototriton limnospectator	X			
Oedipina gephyra		X		
Oedipina stuarti				X
Atelophryniscus chrysophorus		X		
Bufo leucomyos	X			
Hyalinobatrachium cardiacalyptum	X			
Hyalinobatrachium crybetes				X
Duellmanohyla salvavida		X		
Hyla catracha		X		
Hyla insolita	X			
Plectrohyla chrysopleura		X		
Plectrohyla dasypus		X		
Plectrohyla exquisita	X			
Ptychohyla spinipollex	X			
Eleutherodactylus anciano			X	
Eleutherodactylus aurilegulus	X			
Eleutherodactylus chrysozetetes			X	
Eleutherodactylus coffeus				X
Eleutherodactylus cruzi			X	
Eleutherodactylus emleni			X	
Eleutherodactylus epochthidius		X		
Eleutherodactylus fecundus		X		
Eleutherodactylus merendonensis		X		
Eleutherodactylus milesi			X	
Eleutherodactylus olanchano	X			
Eleutherodactylus omoaensis			X	
Eleutherodactylus operosus				X
Eleutherodactylus pechorum		X		
Eleutherodactylus saltuarius		X		
Eleutherodactylus stadelmani			X	
Leptodactylus silvanimbus		X		
Honduran species otherwise restricted to Nuclear Middle America				
Bolitoglossa conanti	X			
Bolitoglossa dofleini		X		
Bolitoglossa dunni	X			
Bolitoglossa occidentalis			X	
Bolitoglossa rufescens complex	X			
Bolitoglossa synoria		X		
Oedipina elongata				X
Oedipina ignea		X		
Oedipina taylori				X
Duellmanohyla soralia		X		

Continued on page 29.

Table 3. Continued.

Species	Stable	Declining	Extinct or Extirpated	No Data
Hyla bromeliacia	X			
Hyla salvaje		X		
Plectrohyla guatemalensis		X		
Plectrohyla hartwegi				X
Plectrohyla matudai		X		
Plectrohyla psiloderma		X		
Ptychohyla hypomykter		X		
Ptychohyla salvadorensis	X			
Triprion petasatus				X
Eleutherodactylus chac	X			
Eleutherodactylus charadra	X			
Eleutherodactylus lauraster	X			
Eleutherodactylus rostralis	X			
Hypopachus barberi	X			
Rana maculata	X			

DOI: 10.1514/journal.arc.0000012.t003

Table 4. Current status of populations of Honduran reptile endemics and species otherwise restricted to Nuclear Middle America. Stable = at least some populations stable; Declining = all populations believed to be declining. Extinct category applies to Honduran endemics; extirpated category applies to Nuclear Middle American endemics (excluding those endemic to Honduras).

Species	Stable	Declining	Extinct or Extirpated	No Data
Honduran endemics				
Abronia salvadorensis		X		
Celestus montanus				X
Celestus scansorius				X
Phyllodactylus palmeus	X			
Sphaerodactylus dunni	X			
Sphaerodactylus rosaurae	X			
Ctenosaura bakeri	X			
Ctenosaura melanosterna	X			
Ctenosaura oedirhina	X			
Norops amplisquamosus	X			
Norops bicaorum	X			
Norops cusuco	X			
Norops johnmeyeri	X			
Norops kreutzi		X		
Norops loveridgei	X			
Norops muralla		X		
Norops ocelloscapularis		X		
Norops pijolensis	X			
Norops purpurgularis	X			
Norops roatanensis	X			
Norops rubribarbaris				X
Norops sminthus	X			
Norops utilensis	X			
Norops wampuensis		X		
Norops yoroensis	X			
Norops zeus	X			
Typhlops stadelmani		X		
Enulius bifoveatus		X		
Enulius roatanensis				X
Geophis damiani				X
Omoadiphas aurula				X

Continued on page 30.

Table 4. Continued.

Species	Stable	Declining	Extinct or Extirpated	No Data
Oxybelis wilsoni	X			
Rhadinaea tolpanorum				X
Tantilla lempira		X		
Tantilla tritaeniata		X		
Micrurus ruatanus				X
Bothriechis marchi		X		
Honduran species otherwise restricted to Nuclear Middle America				
Abronia montecristoi		X		
Celestus bivittatus		X		
Mesaspis moreletii	X			
Corytophanes percarinatus		X		
Ctenosaura flavidorsalis	X			
Norops crassulus	X			
Norops heteropholidotus	X			
Sphenomorphus incertus	X			
Ungaliophis continentalis				X
Dryadophis dorsalis	X			
Geophis fulvoguttatus		X		
Leptophis modestus		X		
Ninia espinali		X		
Rhadinaea kinkelini		X		
Rhadinaea lachrymans				X
Rhadinaea montecristi	X			
Sibon carri		X		
Tantilla impensa		X		
Tantilla taeniata		X		
Thamnophis fulvus	X			
Tropidodipsas fischeri		X		
Bothriechis thalassinus		X		

DOI: 10.1514/journal.arc.0000012.t004

tion status of reptiles endemic to Honduras or otherwise restricted to Nuclear Central America. Thirty-seven species of reptiles are endemic to Honduras (Table 4). Of these 37 species, only 19 species (51.4%) are thought to have stable populations. Ten (27.0%) are considered to have declining populations, primarily on the basis of destruction of habitat within their ranges. Finally, eight species (21.6%) are poorly known enough so that we are uncertain of their status.

The ten endemic reptile species considered to have declining populations have EVS ranging between 12 and 16 (mean 14.9). The EVS for the 19 endemics thought to have stable populations range from 14 to 19 (mean 15.4), which is higher than the mean for those species thought to have declining populations. It is interesting that the reptilian endemics thought to have stable populations also have a higher mean EVS than those thought to have declining populations. The implication of these data is same as that for the analogous data for amphibians. The populations of these endemics need to be monitored carefully, inasmuch as all have scores indicating high vulnerability to environmental pressures.

We also determined the population status for those reptile species not endemic to Honduras but restricted in distribution to Nuclear Middle America. Of these 22 species, only eight (36.4%) are considered to have stable populations, at least somewhere in their known ranges in Honduras. Twelve species (54.5%) are thought to have declining populations. Finally, two species (9.1%) are too poorly known to judge their current population status.

The 12 Nuclear Middle American reptile species that appear to have declining populations have EVS ranging between ten and 15 (mean 12.8). Following the same pattern as indicated above, the EVS for the eight species appearing to have stable populations range from 12 to 14 (mean 12.9), which is slightly higher than the mean for the declining population Nuclear Middle American species. The populations of these species also need to be closely monitored.

In general, it should be understood that the population status of amphibian and reptile species in Honduras potentially can change relatively rapidly. As habitats are degraded, the fabric of community structure unravels. The community inhabitants depend on the integrity of this structure in order to obtain the materials and energy necessary to support their life processes. Thus, they are links in biogeochemical cycles and food webs, through which these materials and energy move,

respectively. Thus, for example, given that amphibian populations are undergoing apparent increasing decline, this can be expected to adversely affect the populations of amphibian-eating snakes. In turn, decline of these snake populations should affect the populations of ophiophagous snakes, and so on. Thus does the straight edge of much human thinking cut deeply.

Plates 2-14 show some of the primary forest left in Honduras, plus some of the extensive deforestation taking place in the country. Plates 15-18 show some Honduran endemic species now feared extinct. Plates 19-38 show some of the Honduran endemic species in which all known populations are believed to be declining. Finally, plates 39-50 show some of the Nuclear Middle America-restricted species (exclusive of the Honduran endemics) in which all known populations are believed to be declining.

Recommendations

Biodiversity decline is one of the most serious environmental problems, if not the most serious (Wilson et al. 2001). Since it is a problem, it cries out for solutions. Unfortunately, one of the tenets of the problem solving critical thinking strategy (see Chaffee 1994 for a description of the strategy) is that a problem *cannot* be solved by simply treating its symptoms. Biodiversity decline is a symptom of habitat loss and degradation, in turn a symptom of runaway human population growth. Uncontrolled population growth is, in turn, a symptom of the mismanaged human mind, to use a phrase coined by E. O. Wilson (1988). The "cascade of deeper problems arising within the human psyche" (Wilson et al. 2001, p. 109) referred to by E. O. Wilson (1988) has been explored at length by L. D. Wilson in a series of papers (1997 a, b, 1998, 1999, 2000, 2001). L. D. Wilson (2001) concluded, after a lengthy argument presented in this series, that the sustainable society described by the better environmental science texts (see for example Miller 2001, and Raven and Berg 2001) will *only* come about (if it ever does) by a fundamental reform of the educational process, so as to enable us to use education as a kind of species-wide psychotherapy. This view, then, treats the "mismanagement of the human mind" (E. O. Wilson 1988) as a pervasive psychological illness in need of broad-based therapy.

Until and unless the "mismanaged human mind" is treated successfully, then we argue that none of the problems that cascade from it, which are, after all, the persistent problems of humankind, will ever encounter workable and lasting solutions. Having said this, then it must be understood that the recommendations we outline below will *only* work if the geometrically advancing problems of uncontrolled human population growth and its corollaries, habitat loss and degradation, are solved. If not, then the exercise below is merely a monument to futility.

Given the above, we have to assume that it *is* possible to guard the integrity of established biotic reserves in Honduras. Based on our decades-long field experience, this is only happening in a limited way. It is still the case that most biotic reserves in the country exist only on paper, without the appropriate resources dedicated to establish boundaries, hire personnel to police them, build facilities for housing administrative, scientific, and security personnel, and fund the scientific studies necessary to make such reserves sustainable. This situation will have to change and change rapidly, for the pressure of a 25-year doubling time will brook no idleness.

It is also evident that we have been idle too long, and that the study of the Honduran herpetofauna has turned a corner into a torturous maze from which there is no easy exit. It is already clear, as is discussed above, that a new era has been breached—one in which advances in our cataloguing of the herpetodiversity of Honduras is being offset by documented losses of that same diversity over the last decade or so. We are, thus, fighting an uphill battle on very slippery slopes.

In full light of the provisos identified in this section above, the following recommendations concerning the protection of the members of the Honduran herpetofauna are made:

- The system of biotic reserves should be expanded to include areas for protection of species not currently known to reside in any legally established reserve. The locations of such areas are discussed by Wilson et al. (2001) and McCranie and Wilson (2002). Of the Honduran endemics, there are 14 such species. For the Nuclear Middle American species, seven species are involved.
- The entire system should be evaluated to ascertain the health of the populations of amphibians and reptiles resident within the various reserves. At least an initial effort can be accomplished by use of Rapid Ecological Assessment Program methodology (see Parker and Bailey 1991).
- Following this evaluation, the system of reserves should be adjusted to the extent possible to provide maximal protection of the remaining populations of resident amphibians and reptiles. Undoubtedly, this step also would involve establishment of additional reserves. Wilson et al. (2001) and McCranie and Wilson (2002) provide some guidance for such decisions.
- Steps then should be taken to clearly identify the limits of the reserves, build facilities to house personnel, involve local people in planning and decision making, make employment available to local people, and put the resulting revenues into local communities for future improvements. Meyer and Meerman (2001) discussed this type of "participatory" management strategy, which they advocate to replace the traditional "exclusionary" management strategy maintained by them to be ineffective over the long term. These steps, which need to occur as rapidly as possible, will obviously require appropriate allocation of governmental funds. The administration of the new Honduran president, Ricardo Maduro Joest, is just beginning. It remains to be seen what priority is established by the new government to address these issues.
- Once facilities are available for housing personnel, then the longer-term scientific survey work and other sorts of scientific studies can begin, with the goal of establishing the biological worth of the various reserves. Opportunities for cooperation in such studies between resident and foreign scientists should be

explored. We continue to explore such collaborations with various Honduran biologists.

- With completion of facilities and scientific studies can come educational and ecotourist programs, with the goal of making the reserves economically self supporting. Again, cooperative undertakings should be encouraged. Such steps would involve reaching out to various Honduran and foreign governmental and nongovernmental organizations.
- Our strongest recommendation is that the steps outlined above be taken with all dispatch possible. We have demonstrated that populations of a highly significant number of species of Honduran amphibians and reptiles are already in decline or have disappeared, especially of the most important segment containing the endemic species and those whose distribution is otherwise restricted to Nuclear Middle America. In addition, deforestation has been demonstrated to be increasing at an exponential rate, commensurate with the increase in human population. Deforestation is the principal type of habitat destruction in Honduras, which is, in turn, the major threat to the highly distinctive and important Honduran herpetofauna. There is, in the final analysis, no time to dawdle.

"We must learn to use our intelligence to live more lightly on the land, so that we do not degrade the only home we have—and the only one we can leave to our children."

E. O. Wilson and D. L. Perlman
***Conserving Earth's Biodiversity*, 2000**

Acknowledgments.—Over the decades that we have worked on the herpetofauna of Honduras, we have incurred indebtedness to uncounted individuals and organizations. First and foremost, this work would not have been possible without the support of the personnel of Recursos Naturales Renovables and Corporación Hondureña de Desarrollo Forestal (COHDEFOR), who made the necessary collecting and export permits available to us over the years. In addition, our good friend Mario R. Espinal has acted as our agent in Honduras to assure that the gaining of these permits went as smoothly as possible, that vehicles were ready when we needed them, and that other myriad details upon which the success of our field work depended were appropriately managed. Finally, it has been our great and continuing pleasure to work with uncounted Hondurans who have made we *gringos* feel welcome in what is, in a very real sense, our second home. Without the unstinting efforts of these Honduran friends, we would never have unraveled the secrets of the animals to which we have devoted our scientific lives.

We also wish to thank Nidia Romer, who kindly translated the Abstract into Spanish for use as the Resumen. Finally, we owe a sincere debt of gratitude to Louis Porras, Jay M. Savage, and Jack W. Sites, the reviewers of this paper, whose suggestions materially improved our presentation.

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Manuscript received: 21 December 2001; Accepted: 4 April 2002
Published online: October 2003; Printed: January 2004

Amphibian and Reptile Conservation 3(1):34-48.
DOI: 10.1514/journal.arc.0000013 (332KB)

The herpetofauna of the cloud forests of Honduras

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Abstract.—**The cloud forest amphibians and reptiles constitute the most important herpetofaunal segment in Honduras, due to the prevalence of endemic and Nuclear Middle American-restricted species. This segment, however, is subject to severe environmental threats due to the actions of humans. Of the 334 species of amphibians and reptiles currently known from Honduras, 122 are known to be distributed in cloud forest habitats. Cloud forest habitats are found throughout the mountainous interior of Honduras. They are subject to a Highland Wet climate, which features annual precipitation of >1500 mm and a mean annual temperature of <18°C. Cloud forest vegetation falls into two Holdridge formations, the Lower Montane Wet Forest and Lower Montane Moist Forest. The Lower Montane Wet Forest formation generally occurs at elevations in excess of 1500 m, although it may occur as low as 1300+ m at some localities. The Lower Montane Moist Forest formation generally occurs at 1700+ m elevation. Of the 122 cloud forest species, 18 are salamanders, 38 are anurans, 27 are lizards, and 39 are snakes. Ninety-eight of these 122 species are distributed in the Lower Montane Wet Forest formation and 45 in the Lower Montane Moist Forest formation. Twenty species are distributed in both formations. The cloud forest species are distributed among restricted, widespread, and peripheral distributional categories. The restricted species range as a group in elevation from 1340 to 2700 m, the species that are widespread in at least one of the two cloud forest formations range as a group from sea level to 2744 m, and the peripheral species range as a group from sea level to 1980 m. The 122 cloud forest species exemplify ten broad distributional patterns ranging from species whose northern and southern range termini are in the United States (or Canada) and South America, respectively, to those species that are endemic to Honduras. The largest segment of the herpetofauna falls into the endemic category, with the next largest segment being restricted in distribution to Nuclear Middle America, but not endemic to Honduras. Cloud forest species are distributed among eight ecophysiographic areas, with the largest number being found in the Northwestern Highlands, followed by the North-Central Highlands and the Southwestern Highlands. The greatest significance of the Honduran herpetofauna lies in its 125 species that are either Honduran endemics or otherwise Nuclear Middle American-restricted species, of which 83 are distributed in the country's cloud forests. This segment of the herpetofauna is seriously endangered as a consequence of exponentially increasing habitat destruction resulting from deforestation, even given the existence of several biotic reserves established in cloud forest. Other, less clearly evident environmental factors also appear to be implicated. As a consequence, slightly over half of these 83 species (50.6%) have populations that are in decline or that have disappeared from Honduran cloud forests. These species possess biological, conservational, and economic significance, all of which appear in danger of being lost.**

Resumen.—**Los anfibios y reptiles de los bosques nublados constituyen el segmento más importante de la herpetofauna de Honduras, debido a la prevalencia de especies endémicas y restringidas a la Mesoamérica Nuclear. Este segmento, sin embargo, está sometido a fuertes amenazas medioambientales debido a acciones humanas. De las 334 especies de anfibios y reptiles que se conocen en Honduras en el presente, 122 se conocen que están distribuidas en las habitaciones de los bosques nublados. Las habitaciones del bosques nublados se encuentran a través de las montañas del interior de Honduras. Ellos están sujetos a un clima lluvioso de tierras altas, el cual tiene una precipitación anual de más de 1500 mm y una temperatura anual promedia de menos de 18 grados centígrados. La vegetación de los bosques nublados cae entre dos formaciones de Holdridge, la de Bosque Lluvioso Montano Bajo y la de Bosque Húmedo Montano Bajo. La formación de Bosque Lluvioso Montano Bajo generalmente occure a elevaciones en exceso de 1500 m, aunque puede ocurrir tan bajo como 1300 m en algunas localidades. La formación Bosque Húmedo Montano Bajo generalmente ocurre a 1700 m o más de elevación. De las 122 especies de los bosques nublados, 18 son salamandras, 38 son anuros, 27 son lagartijas y 39 son culebras. Noventa y ocho de estas 122 especies están distribuidas en la formación Bosque Lluvioso Montano Bajo y 45 en la formación Bosque Húmedo Montano Bajo. Viente especies están distribuidas en ambas formaciones. Las especies de los bosques nublados están distribuidas entre categorías distribucionales restringidas, amplias, y periféricas. Las especies restringidas se encuentra como grupo en un rango de elevaciones de los 1340 a los**

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2700 m, las especies que tienen una distribución amplia en al menos entre una de las dos formaciones de los bosques nublados como grupo tiene un rango desde el nivel del mar hasta 2744 m, y las especies periféricas como grupo tiene un rango desde el nivel del mar hasta 1980 m. Las 122 especies de los bosques nublados ejemplifican 10 patrones distribucionales amplios con rangos de especies para las cuales los rangos terminales norteño y sureño están en los Estados Unidos (o Canadá) y América del Sur, respectivamente, hasta esas especies que son endémicas de Honduras. El segmento más grande de la herpetofauna cae en la categoría endémica, con el proximo segmento más grande siendo restringido en distribución a la Mesoamérica Nuclear, pero no endémico de Honduras. Las especies de los bosques nublados están distribuidas entre ocho áreas ecofisiográficas, con el grupo más grande encontrandose en las tierras altas hacia el noroeste y seguido por las tierras altas norte-central y las tierras altas del suroeste. La importancia más grande de la herpetofauna hondureña cae en sus 125 especies que son endémicas de Honduras o de otra manera restringidas a la Mesoamérica Nuclear, de las cuales 83 están distribuidos en los bosques nublados del país. Este segmento de la herpetofauna está seriamente amenazado a consequencia de la destrucción exponencial de sus habitaciones, el cual es el resultado de la destrucción de los bosques, aunque existen varias reservas bióticas establecidas en los bosques nublados. Otros factores medioambientales menos claramente evidentes parecen estar implicados. Como consequencia, un poco más de la mitad de estas 83 especies (50.6%) tiene poblaciones que están disminuyendo o que han desaparecidos de los bosques nublados hondureños. Estas especies poseen significancia biológica, de conservación, y económica, todas las cuales parecen estar en peligro de ser perdidas.

Key words. *Cloud forests, Honduras, amphibians, reptiles, herpetofauna*

Introduction

After decades of warnings by environmental scientists, population biologists, and demographers (see especially Osborn 1948; Carson 1962; Ehrlich 1968; Meadows et al. 1972), it is becoming increasingly apparent to an enlarging group of people that the Earth is entering a sixth spasm of mass extinction of life, at least comparable to and, perhaps, exceeding in scope the five episodes that have preceded it (Ehrlich and Ehrlich 1981, 1996; E. Wilson 1988, 1992; E. Wilson and Perlman 2000). What has come to be known as biodiversity decline is best documented in areas where the flora and fauna are most completely understood, e.g., the United States, and correspondingly less well understood in the areas of the world supporting the greatest amount of biodiversity—the tropics.

To use as an example the country that has been the focus of our research for more than three decades—Honduras—and the group upon which we have specialized—the herpetofauna, it is evident that the modern study of the Honduran herpetofauna began with the research of John R. Meyer that led to his dissertation, which appeared in 1969. Meyer's (1969) study documented a known herpetofauna of 196 species, including 53 amphibians and 143 reptiles. The current tally is 334 species, including 117 amphibians and 217 reptiles (McCranie and Wilson 2002; Wilson and McCranie 2002). With respect to the total count, there has been an increase of 138 species or 41.3% in the 33 years since 1969 to the present (although Meyer did not include five marine turtles species then known to occur in Honduran waters, nor five species of reptiles known in Honduran territory only from the Swan Islands, which are included in the total count of 334). Meyer (1969) included 35 species in the cloud forest herpetofauna of Honduras, although one species included by him (*Ungaliophis continentalis*) is not so included by us. Presently, we can document the presence of 122 species in one or more cloud forest regions of Honduras. This increase of 88 species (or 72.1% of the total now known) is largely a result of our field work in the country. Forty-two of these 88 species (47.7%) have been described as new species since 1979. In addition, populations of two species reported from cloud forest by Meyer (1969) have been described as new species (*Ptychohyla spinipollex* and *Ninia lansbergi* cloud forest populations of Meyer equal *P. hypomykter* and *N. espinali*, respectively).

There is still significant mountainous terrain in Honduras supporting cloud forest that has been incompletely sampled herpetofaunally. Such is the case with the Yoro Highlands, the Agalta Highlands, and the Santa Barbara Highlands. Given the frequency with which new taxa have been added to the Honduran cloud forest herpetofauna (2.3 taxa per year since 1972), it can be expected that additional forms await discovery in these yet poorly known ranges.

Acting in contraposition, however, is a more recent trend toward decline of herpetofaunal populations, which has been documented in Honduras by Wilson and McCranie (1998, 2003 a and b) and McCranie and Wilson (2002). This trend has been most evident in regions of the country in excess of 900 m in elevation and has most obviously affected the species composing the most distinctive group, i.e., those that are endemic to Honduras or otherwise restricted in distribution to Nuclear Middle America. Of the 125 species belonging to this group, 52 or 41.6% are considered to have declining populations, to be extinct, or to be extirpated in Honduras. This trend is extremely alarming, given the fact that the 125 species involved do not occur outside of Nuclear Middle America.

In light of the importance of the cloud forest environments of Honduras as centers of herpetodiversity and the accumulating evidence of the decline and disappearance of a significant amount of this diversity, it is the purpose of this paper to update our current understanding of the composition and distribution (both geographic and ecological) of this herpetofauna, to discuss its biodiversity significance, to examine its current conservation status, and to speculate on the future for this segment of the Honduran herpetofauna.

Materials and methods

Fieldwork upon which this paper is based has been conducted by one or both of us since 1968. The material collected has been reported in a number of publications written by one or both of us since 1971 and summarized in Meyer and Wilson (1971, 1973), Wilson and Meyer (1985), and McCranie and Wilson (2002, *in preparation*).

The Coefficient of Biogeographic Resemblance algorithm (Duellman 1990) was used to demonstrate herpetofaunal relationships among the cloud forest ecophysiographic areas examined in this study. The formula is $CBR = 2C/(N_1 + N_2)$, where C is the number of species in common to both formations, N_1 is the number of species in the first formation, and N_2 is the number of species in the second formation.

Physiography

Honduras contains within its borders a major segment of the mountains of Nuclear Middle America (West 1964). Many of the ranges found within the country have portions high enough to support cloud forest (Fig. 1). Descriptions of the physiography of Honduras have appeared in Wilson and Meyer (1985) and McCranie and Wilson (2002), so this description will be limited to only those mountain ranges upon which cloud forest vegetation occurs.

Elevations high enough to support cloud forest are distributed throughout the *Serranía*, the mountainous interior of Honduras, which is a portion of the Nuclear Middle American highlands (Fig. 1). The *Serranía* is traditionally divided into the Northern Cordillera and the Southern Cordillera, the latter distinguishable from the former by an overlay of Pliocene volcanic ejecta deposits (Wilson and Meyer 1985). Both of these cordilleras are interrupted by an irregular graben, called the Honduran depression, traceable from north to south through the Ulúa-Chamelecón Plain, the Valley of Humuya, the Comayagua Plain, and the Valley of Goascorán (Wilson and Meyer 1985). In effect, these physiographic features divide the mountainous interior of Honduras into four sectors, three of which are recognized as ecophysiographic areas on the basis of this division. They are the Northwestern Highlands, the Southwestern Highlands, and the Southeastern Highlands. The fourth sector is significantly larger than any of the other three and is broken into four ecophysiographic areas (see below).

Climate

Savage (2002), in his opus on the amphibians and reptiles of Costa Rica, noted "the term cloud forest is often applied to forests that develop at an altitude where the temperature (6 to 10°C) causes water condensation that produces clouds, fog, and rain. This zone may be at any elevation, and its degree of development is related to the amount of water vapor in the air. Cloud forests usually occur where there are prevailing onshore winds that have their air masses uplifted along ocean-facing mountains. In Central America, cloud forests develop principally on the windward slopes affected by the northeast trade winds. In the Holdridge (1967) system, cloud forests are regarded as atmospheric association within bioclimates that, in Central America, usually develop in the lower portion of the lower montane life zone under the influence of strong prevailing winds. During much of the year these forests receive precipitation in the form of light mists. In the drier seasons, much of the time they are enveloped in dense, dripping fog."

Areas supporting cloud forest in Honduras are generally subject to a Highland Wet climatic regime (Wilson and Meyer 1985). This climatic type is broadly characterized by annual rainfall of >1500 mm and a mean annual temperature of <18°C. The cloud forest regions occurring in the Southern Cordillera generally receive less rainfall than do those in the Northern Cordillera, part of the general effect of the dissipation of moisture in clouds carried by the prevailing winds arising over the Caribbean Sea as they sweep inland.

Climatic data are available for the nuclear zone and the buffer zone of Parque Nacional El Cusuco, a cloud forest reserve in the Sierra de Omoa in northwestern Honduras (Fundación Ecologista "Hector Rodrigo Pastor Fasquelle" 1994). Annual precipitation in the nuclear zone is 2995 mm and in the buffer zone 2580 mm. The rainiest months, in both cases, are October, November, and December, accounting for 45.1% of total rainfall in both zones. The least rainiest months are March, April, and May, when only 12.1% of rainfall occurs in both zones. Monthly temperatures range from 12.9°C in December to 20.2°C in April, with a mean of 16.7°C, in the nuclear zone and from 17.5°C in December to 23.1°C in April, with a mean of 20.6°C, in the buffer zone.

Vegetation

The vegetation of the Honduran cloud forests is referable to two forest formations, as slightly modified from the work of Holdridge (1967), which differ from one another on the basis of the amount of annual precipitation (Wilson and Meyer 1985). The formation characteristic of the cloud forests of the Northern Cordillera is the Lower Montane Wet Forest formation. It is characterized by annual precipitation of >2000 mm. The formation typical of the cloud forests of the Southern Cordillera is the Lower Montane Moist Forest formation. It features an annual precipitation of <2000 mm.

Wilson and McCranie (*in preparation* a) presented information on the vegetation of Parque Nacional El Cusuco (Lower Montane Wet Forest formation), as follows: "Fundación Ecologista 'Hector Rodrigo Pastor Fasquelle' (1994) indicated that this forest formation, called 'Zona de Vida Bosque Muy Húmedo Montano Bajo Sub-Tropical,' is characterized by the presence of three strata. The uppermost stratum consists of a closed canopy of trees attaining heights of 35 to 40 m of the following species: *Quercus* spp.; *Podocarpus oleifolius*; *Clusia massoniana*; and *Liquidambar styraciflua*. The middle stratum is composed of the forgoing species lying in the shade of the taller conspecifics mixed with *Persea vesticula* and *Myrica cerifera*. The lowermost stratum is comprised of seedlings of the species in the middle and uppermost strata intermixed with palms such as *Chamaedorea costaricana* and *C. oblongata*, as well as *Geonoma congesta* and a great variety of ferns. Many epiphytic orchids, bromeliads, and mosses are present, as well as lianas and vines."

Espinal et al. (2001) presented similarly limited data on floristic composition at two sites (at 1570 and 1650 m) in Parque Nacional La Muralla (both in Lower Montane Wet Forest formation), located in the Ocote Highlands of the northwestern portion of the department of Olancho. They stat-

Table 1. Geographic and ecological distribution, relative abundance, and conservation status of the cloud forest herpetofauna (122 species) of Honduras. Abbreviations include: Formations—LMWF = Lower Montane Wet Forest formation, LMMF = Lower Montane Moist Forest formation; Forest Formation Distribution—W = widespread in that formation, R = restricted to that formation, P = peripherally distributed in that formation; Primary Microhabitat—A = arboreal, T = terrestrial, F = forest inhabitant, P = pondside inhabitant, S = streamside inhabitant; Relative Abundance—C = common, I = infrequent, R = rare; Conservation Status—S = stable populations at least at one cloud forest locality, D = all known cloud forest populations declining, E = extinct or extirpated from all known cloud forest localities, N = no data on population status. See text for explanation of Broad Distribution Pattern abbreviations.

Species	LMWF	LMMF	Elevational Range (m)	Broad Distribution Pattern	Primary Microhabitat	Relative Abundance[1]	Conservation Status
Salamanders (18 species)							
Bolitoglossa carri	—	R	1840-2070	J	A, F, S	C	D
Bolitoglossa celaque	—	R	1900-2620	J	A, T, F, S	C	S
Bolitoglossa conanti	W	W	1370-2000	I	A, F	C	S
Bolitoglossa decora	R	—	1430-1550	J	A, F	C	S
Bolitoglossa diaphora	R	—	1470-2200	J	A, F	I	S
Bolitoglossa dofleini	P	—	650-1370	I	T, F	I	D
Bolitoglossa dunni	W	—	1200-1600	I	A, F	I	S
Bolitoglossa longissima	R	—	1840-2240	J	A, F	C	S
Bolitoglossa porrasorum	W	—	980-1920	J	A, F, S	C	S
Bolitoglossa rufescens complex	P	—	30-1400	I	A, F	C	D
Bolitoglossa synoria	—	R	2150	I	A, S	R	D
Cryptotriton nasalis	W	—	1220-2200	J	A, F	R	S
Dendrotriton sanctibarbarus	W	—	1829-2744	J	A, T, F	C	S
Nototriton barbouri	W	—	860-1990	J	A, F	C	S
Nototriton lignicola	R	—	1760-1780	J	T, F	I	S
Nototriton limnospectator	R	—	1640-1980	J	A, T, F	C	S
Oedipina cyclocauda	P	—	0-1780	H	T, F	I	S
Oedipina gephyra	R	—	1580-1810	J	T, F	C	D
Anurans (38 species)							
Atelophryniscus chrysophorus	W	—	750-1760	J	T, F, S	C	D
Bufo coccifer	—	W	0-2070	E	T, P	C	S
Bufo leucomyos	W	—	0-1600	J	T, F	C	S
Bufo valliceps	P	—	0-1610	E	T, F, P	C	S
Hyalinobatrachium fleischmanni	P	—	0-1550	D	A, S	C	D
Duellmanohyla soralia	P	—	40-1570	I	A, S	C	D
Hyla bromeliacia	W	—	1250-1790	I	A, F	C	S
Hyla catracha	—	R	1800-2160	J	A, S	C	D
Hyla insolita	R	—	1550	J	A, S	C	S
Hyla salvaje	R	—	1370	I	A, F	R	D
Phrynohyas venulosa	P	—	0-1610	D	A, T, P	C	S
Plectrohyla chrysopleura	W	—	930-1550	J	A, T, S	I	D
Plectrohyla dasypus	R	—	1410-1990	J	A, S	C	D
Plectrohyla exquisita	R	—	1490-1680	J	A, S	C	S
Plectrohyla guatemalensis	W	W	950-2600	I	A, S	C	D
Plectrohyla hartwegi	—	R	1920-2700	I	A, F, S	I	N
Plectrohyla matudai	P	W	770-1850	I	T, S	C	D
Plectrohyla psiloderma	—	R	2450-2530	I	A, T, S	C	D
Ptychohyla hypomykter	W	W	620-2070	I	A, S	C	D
Ptychohyla salvadorensis	—	W	1440-2050	I	A, T, S	C	S
Ptychohyla spinipollex	P	—	160-1580	J	A, S	C	S
Smilisca baudinii	P	—	0-1610	B	A, P	C	S
Eleutherodactylus anciano	—	W	1400-1840	J	T, S	I	E
Eleutherodactylus aurilegulus	P	—	50-1550	J	T, S	C	E
Eleutherodactylus charadra	P	—	30-1370	I	T, S	C	E
Eleutherodactylus cruzi	R	—	1520	J	T, S	R	E
Eleutherodactylus emleni	—	W	800-2000	J	T, S	R	E
Eleutherodactylus laevissimus	—	P	100-1640	H	T, S	I	E
Eleutherodactylus loki	R	—	1370	F	T, F	R	N

Continued on page 38.

Table 1. Continued.

Species	LMWF	LMMF	Elevational Range (m)	Broad Distribution Pattern	Primary Microhabitat	Relative Abundance[1]	Conservation Status
Eleutherodactylus milesi	W	—	1050-1720	J	T, S	C	E
Eleutherodactylus rostralis	W	—	1050-1800	I	T, F	I	D
Eleutherodactylus saltuarius	R	—	1550-1800	J	T, F	I	D
Eleutherodactylus stadelmani	W	—	1125-1900	J	T, S	C	E
Leptodactylus silvanimbus	—	W	1470-2000	J	T, P	C	D
Hypopachus barberi	—	W	1470-2070	I	T, P	C	S
Hypopachus variolosus	P	—	0-1610	B	T, P	C	S
Rana berlandieri[2]	P	W	0-2200	C	T, P	C	S
Rana maculata	W	W	40-1980	I	T, S	C	D
Lizards (27 species)							
Abronia montecristoi	R	—	1370	I	A, F	R	D
Abronia salvadorensis	—	R	2020-2125	J	A, T, F	R	D
Celestus bivitattus	—	P	1510-1980	I	T, F	C	D
Celestus montanus	P	—	915-1372	J	A, F	R	N
Celestus scansorius	R	—	1550-1590	J	A, F	R	N
Mesaspis moreletii	W	W	1450-2530	I	T, F	C	S
Sceloporus malachiticus	W	W	540-2530	H	A, F	C	S
Norops amplisquamosus	R	—	1530-1720	J	A, F	C	S
Norops crassulus	—	W	1200-2020	I	A, F	C	S
Norops cusuco	R	—	1550-1935	J	A, F	C	S
Norops heteropholidotus	—	R	1860-2200	I	A, F	C	S
Norops johnmeyeri	R	—	1340-1825	J	A, F	C	S
Norops kreutzi	R	—	1670-1690	J	A, F	I	D
Norops laeviventris	W	W	1150-1900	E	A, F	I	S
Norops loveridgei	P	—	ca. 550-1600	J	A, F	I	S
Norops muralla	R	—	1440-1740	J	A, F	C	D
Norops ocelloscapularis	P	—	1150-1370	J	A, F	I	D
Norops petersii	R	—	1340-1370	F	A, F	R	N
Norops pijolensis	W	—	1180-2050	J	A, F	C	S
Norops purpurgularis	R	—	1550-2040	J	A, F	C	S
Norops rubribarbaris	R	—	1700	J	T, S	R	N
Norops sminthus	—	W	ca. 1450-2200	J	A, F	C	S
Norops tropidonotus	P	P	0-1900	F	A, T, F	C	S
Norops uniformis	P	—	30-1370	F	A, T, F	C	D
Norops yoroensis	P	—	1180-1600	J	A, F	I	S
Sphenomorphus cherriei	P	P	0-1860	E	T, F	C	S
Sphenomorphus incertus	P	—	1350-1670	I	T, F	R	S
Snakes (39 species)							
Typhlops stadelmani	P	—	850-1370	J	T, F	I	D
Boa constrictor	P	—	0-1370	D	T, F	I	N
Adelphicos quadrivirgatus	P	—	0-1740	F	T, F	C	S
Coniophanes bipunctatus	P	—	0-1370	E	T, P	I	N
Dryadophis dorsalis	W	W	635-1900	I	T, F	I	S
Drymarchon corais	P	—	0-1555	A	T, F	I	N
Drymobius chloroticus	W	W	780-1900	F	T, F, S	I	D
Drymobius margaritiferus	P	—	0-1450	A	T, F, P	C	S
Geophis damiani	R	—	1750	J	T, F	R	N
Geophis fulvoguttatus	W	W	1680-1900	I	T, F	R	D
Imantodes cenchoa	P	—	0-1620	D	A, F	C	S
Lampropeltis triangulum	P	—	0-1370	A	T, F	I	N
Leptodeira septentrionalis	W	W	0-1940	A	A, P, S	I	S
Leptophis ahaetulla	P	—	0-1680	D	A, T, P, S	C	N
Leptophis modestus	—	R	1890-2020	I	T, F	R	D
Ninia diademata	P	—	0-1370	F	T, F	I	D

Continued on page 40.

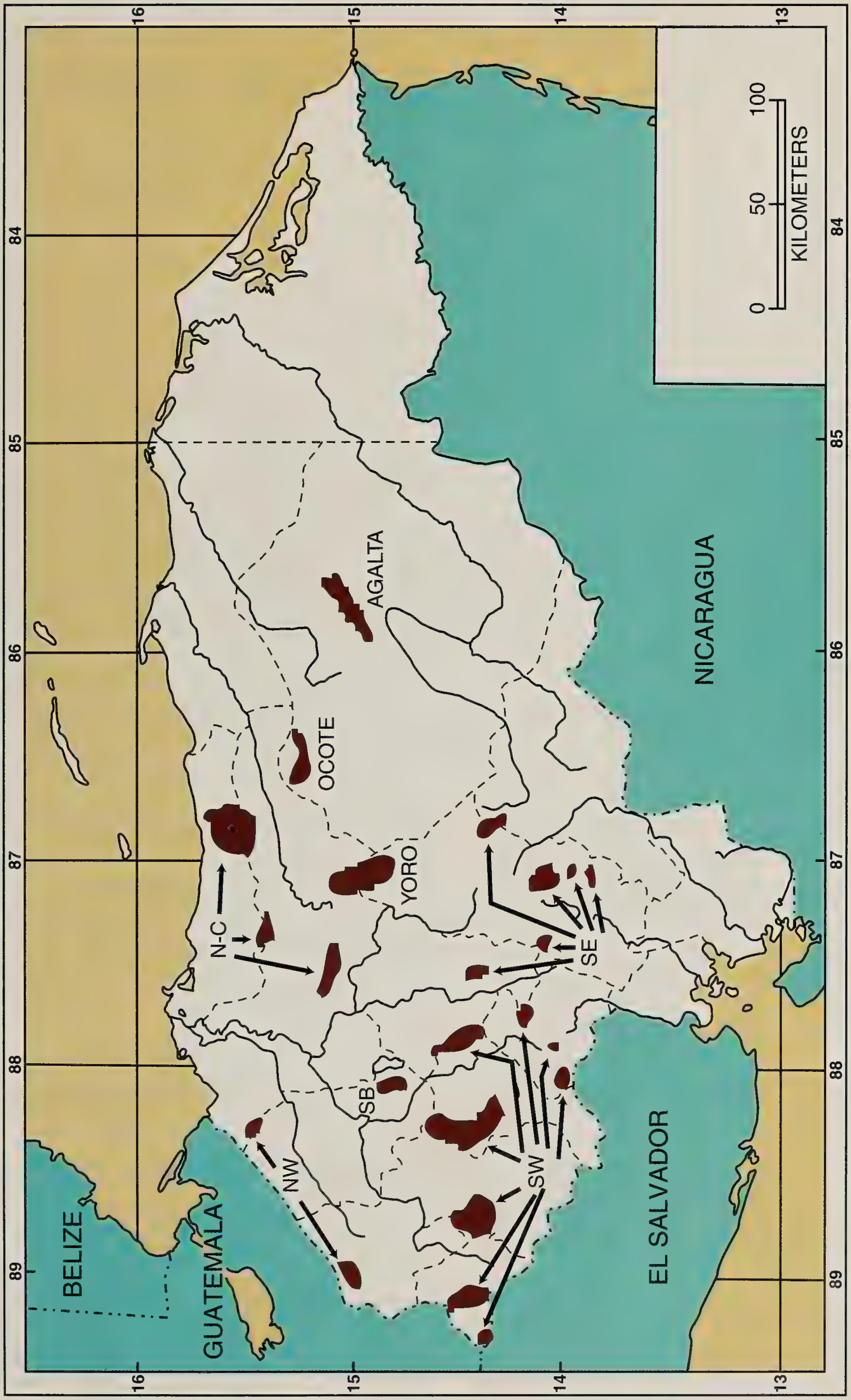

Figure 1. Generalized map of the cloud forest areas of Honduras. Abbreviations are as follows: NW = Northwestern Highlands; N-C = North-Central Highlands; SW = Southwestern Highlands; SE = Southeastern Highlands; SB = Santa Bárbara Highlands; Yoro = Yoro Highlands; Ocote = Ocote Highlands; Agalta = Agalta Highlands.
DOI: 10.1514/journal.arc.0000013.g001

Table 1. Continued.

Species	LMWF	LMMF	Elevational Range (m)	Broad Distribution Pattern	Primary Microhabitat	Relative Abundance[1]	Conservation Status
Ninia espinali	W	W	1590-2242	I	T, F	C	D
Ninia sebae	P	—	0-1650	E	T, F	C	S
Pliocercus elapoides	P	—	0-1670	F	T, F	I	S
Rhadinaea godmani	W	W	1450-2160	H	T, F	I	S
Rhadinaea kinkelini	W	W	1370-2085	I	T, F	I	D
Rhadinaea lachrymans	R	—	2050	I	T, F	R	N
Rhadinaea montecristi	W	W	1370-2620	I	T, F	I	S
Rhadinaea tolpanorum	R	—	1900	J	T, F	R	N
Sibon dimidiatus	P	—	950-1600	E	A, F	I	D
Sibon nebulatus	P	—	0-1690	D	A, F, S	C	S
Stenorrhina degenhardtii	P	—	100-1630	D	T, F	I	S
Storeria dekayi	—	P	635-1900	C	T, F	R	N
Tantilla impensa	W	—	635-ca. 1600	I	T, F	R	D
Tantilla lempira	—	P	1450-1730	J	T, F	I	D
Tantilla schistosa	P	—	950-1680	E	T, F	I	S
Thamnophis fulvus	—	W	1680-2020	I	T, P, S	C	S
Tropidodipsas fischeri	—	W	1340-2150	I	T, F	I	D
Micrurus browni	—	R	1900	F	T, F	R	N
Micrurus diastema	P	—	100-1680	F	T, F	I	S
Micrurus nigrocinctus	P	—	0-1600	G	T, F	C	S
Bothriechis marchi	W	—	ca. 500-1840	J	A, S	I	D
Bothriechis thalassinus	W	W	1370-1750	I	A, S	R	D
Cerrophidion godmani	W	W	ca. 1300-2620	H	T, F	I	S
Total 122 species							

[1]Historical. For example, species that were common at one time during our field experience, but may now be declining or extinct.
[2]LMMF specimens represent *Rana berlandieri* x *Rana forreri* hybrids (see McCranie and Wilson 2002).
DOI: 10.1514/journal.arc.0000013.t001

ed the following (p. 102): "At the 1570 m site, of 38 species with chest-high diameters of 5 cm or more, seven species were considered most important [based on numerical prevalence]. These species, in order of importance, are: *Persea* sp. (aguacate); *Calatola mollis* (nogál); *Quercus sapotaefolia* (encinillo); *Calophyllum brasiliense* (aceite de maría); *Elaeagia auriculata* (oreja de macho); *Quercus skinneri* (bellota); *Chamaedorea neurochlamys* (palma pacaya).

At the 1650 m site, a group of 6 species (out of 30) were judged most important, based on frequency of occurrence. These species, in order of importance, are: *Calophyllum brasiliense* (aceite de maría); *Quercus sapotaefolia* (encinillo); *Persea* sp. (aguacate); *Quercus skinneri* (bellota); *Elaeagia auriculata* (o[reja] de macho); *Alchornea latifolia* (amargoso). Five of these six species are of greatest importance as well at the 1570 m site."

Wilson and McCranie (*in preparation* b) included data on the floristic makeup of the vegetation of the Lower Montane Moist formation in Parques Nacionales de Celaque and La Tigra, as follows: "The undisturbed forest is composed of three strata. The upper stratum is composed of trees 25 to 30 m in height, principally of the species *Quercus skinneri* (bellota), *Liquidambar styraciflua* (liquidámbar), *Pinus pseudostrobus* (pinabete), *P. oocarpa* (ocote), and *Persea* sp. (aguacate sucte). These trees carry a moderate amount of epiphytic mosses, orchids, bromeliads, and aroids. The middle stratum consists of *Quercus* sp. (curtidor), *Q. oleoides* (encino), *Clethra macrophylla* (alámo blanco), *Cedrela oaxacensis* (cedro), *Inga* sp. (guama), and various species of laurals. The lower stratum consists of shrubs belonging to the families Compositae, Myrsinaceae, Rubiaceae, Saurauiaceae, and Verbenaceae and the genera *Cleyera, Miconia, Piper, Psidium,* and *Vismia*."

Composition of the cloud forest herpetofauna

The herpetofauna of the cloud forests of Honduras is known to consist of 122 species (Table 1), including 18 salamanders (14.8% of total), 38 anurans (31.1%), 27 lizards (22.1%), and 39 snakes (32.0%). The salamanders are all members of the family Plethodontidae. The anurans belong to six families, including the Bufonidae (4 species), Centrolenidae (1 species), Hylidae (17 species), Leptodactylidae (12 species), Microhylidae (2 species), and Ranidae (2 species). The lizards are members of four families, the Anguidae (6 species), Phrynosomatidae (1 species), Polychrotidae (18 species), and Scincidae (2 species). The snakes belong to five families, including the Typhlopidae (1 species), Boidae (1 species), Colubridae (31 species), Elapidae (3 species), and Viperidae (3 species).

Distribution and distributional relationships of the cloud forest herpetofauna

Distribution within forest formations

More than twice as many of the 122 cloud forest species are distributed in the Lower Montane Wet Forest formation (98 or 80.3% of total) than in the Lower Montane Moist Forest formation (45 or 36.9%). Twenty-one species (17.2%) are found in both formations (Table 1). The Coefficient of Biogeographic Resemblance (CBR) for these two forest formations is 0.29.

The species distributed in cloud forests fall into three distributional categories, viz., restricted, widespread, and peripheral (Table 1). Restricted species are those whose distribution is limited to a particular cloud forest formation. Widespread species are those that are widespread in distribution in a particular cloud forest formation or both cloud forest formations, as well as, perhaps, outside those forest formations. Finally, peripheral species are those whose distribution is largely peripheral to a particular cloud forest formation.

The Lower Montane Wet Forest formation is inhabited by 26 restricted species (26.5% of the total of 98 in this formation), including six salamanders, seven anurans, ten lizards, and three snakes. Thirty-two species (32.7%) are widespread in this formation, including six salamanders, ten anurans, four lizards, and 12 snakes. Finally, 40 species (40.8%) are peripherally distributed in this formation, including three salamanders, 11 anurans, eight lizards, and 18 snakes.

The Lower Montane Moist Forest formation is home to ten restricted species (22.2% of the total of 45 in this formation), including three salamanders, three anurans, two lizards, and two snakes. Twenty-nine species (64.4%) are widespread in this formation, including one salamander, 11 anurans, five lizards, and 12 snakes. Finally, there are six species (13.3%) peripherally distributed in this formation, including one anuran, three lizards, and two snakes. Notably, there are proportionately more peripheral and widespread species than restricted species in the Lower Montane Wet Forest formation. In the Lower Montane Moist Forest formation, most species are widespread ones, followed by relatively few restricted and peripheral species. The relative prevalence of peripheral species in the Lower Montane Wet Forest formation apparently is due to the grading of this type of cloud forest into highland rain forest (Premontane Wet Forest formation) at elevations usually around 1500 m, whereas the Lower Montane Moist Forest formation grades into upland pine forest (Premontane Moist Forest) typically.

As noted above, 21 species are distributed in both cloud forest formations (Table 1). The largest number of these species (17) are widespread in both formations. Two species are peripheral in distribution in both formations, and, finally, two species are widespread in one formation and peripheral in the other.

Distribution with respect to elevation

The Lower Montane Wet Forest formation is generally found at elevations in excess of 1500 m, although in some locales it occurs at elevations down to 1300+ m. The Lower Montane Moist Forest formation usually occurs at 1700+ m elevation. Thus, it is expected that patterns of elevational occurrence would be related to the patterns of occurrence in the two forest formations elucidated above. That is to say, the widespread and peripheral species would be expected to have broader overall elevational ranges than those whose distribution is restricted to cloud forest vegetation, with the peripheral species more broadly distributed overall than the widespread ones.

The restricted species, as a group, range from 1340 to 2700 m. The mean elevational range for this group of 36 species is 209.6 m. The species that are widespread in at least one of the two cloud forest formations, as a group, range from sea level to 2744 m. The mean elevational range for this group of 44 species is 1000.4 m. The species that occur peripherally in at least one of the two cloud forest formations, as a group, range from sea level to 2200 m. The mean elevational range for this group of 44 species is 1260.3 m (two species are peripheral in one formation and widespread in the other).

Broad distribution patterns

As did Wilson and Meyer (1985), Wilson et al. (2001), and McCranie and Wilson (2002), we placed the cloud forest species into a set of distributional categories based on the entire extent of their geographic range. Two of the categories used by Wilson et al. (2001) do not apply to this paper (marine species and insular and/or coastal species). The applicable categories are as follows:

A. Northern terminus of the range in the United States (or Canada) and southern terminus in South America.
B. Northern terminus of the range in the United States and southern terminus in Central America south of the Nicaraguan Depression.
C. Northern terminus of the range in the United States and southern terminus in Nuclear Middle America.

Table 2. Summary of numbers of taxa exhibiting various Broad Patterns of Geographic Distibution (see text for explanation of categories).

Groups	Broad Patterns of Distribution									
	A	B	C	D	E	F	G	H	I	J
Salamanders (18 species)	—	—	—	—	—	—	—	1	5	12
Anurans (38)	—	2	1	2	2	1	—	1	13	16
Lizards (27)	—	—	—	—	2	3	—	1	6	15
Snakes (39)	4	—	1	5	4	6	1	2	11	5
Totals 122	**4**	**2**	**2**	**7**	**8**	**10**	**1**	**5**	**35**	**48**

DOI: 10.1514/journal.arc.0000013.t002

Table 3. Distribution of the Honduran cloud forest herpetofauna within eight ecophysiographic areas. Abbreviations are: W = widespread in that area; R = restricted to that area; P = peripherally distributed in that area; HL = Highlands.

Species	SE HL	SW HL	N-Central HL	Yoro HL	Ocote HL	Agalta HL	NW HL	Santa Bárbara HL	Total
Bolitoglossa carri	R								1
Bolitoglossa celaque		R							1
Bolitoglossa conanti		P					W		2
Bolitoglossa decora					R				1
Bolitoglossa diaphora							W		1
Bolitoglossa dofleini							P		1
Bolitoglossa dunni							W		1
Bolitoglossa longissima						R			1
Bolitoglossa porrasorum			W						1
Bolitoglossa rufescens complex							P		1
Bolitoglossa synoria		R							1
Cryptotriton nasalis							W		1
Dendrotriton sanctibarbarus								R	1
Nototriton barbouri			W						1
Nototriton lignicola					R				1
Nototriton limnospectator								R	1
Oedipina cyclocauda					W				1
Oedipina gephyra			R						1
Atelophryniscus chrysophorus			W						1
Bufo coccifer	W	W							2
Bufo leucomyos			P	P	W				3
Bufo valliceps							P	P	2
Hyalinobatrachium fleischmanni[1]			P		P				2
Duellmanohyla soralia							P		1
Hyla bromeliacia							W		1
Hyla catracha		R							1
Hyla insolita			R						1
Hyla salvaje							R		1
Phrynohyas venulosa								P	1
Plectrohyla chrysopleura			P						1
Plectrohyla dasypus							R		1
Plectrohyla exquisita							R		1
Plectrohyla guatemalensis	W	W	W		W		P		5
Plectrohyla hartwegi		R							1
Plectrohyla matudai		W					P		2
Plectrohyla psiloderma		R							1
Ptychohyla hypomykter	W	W			W		W		4
Ptychohyla salvadorensis	W	W							2
Ptychohyla spinipollex			P						1
Smilisca baudinii			P	P	P		P	P	5
Eleutherodactylus anciano		P							1
Eleutherodactylus aurilegulus			P		W				2
Eleutherodactylus charadra							P		1
Eleutherodactylus cruzi			R						1
Eleutherodactylus emleni	W								1
Eleutherodactylus laevissimus	P								1
Eleutherodactylus loki							R		1
Eleutherodactylus milesi							W		1
Eleutherodactylus rostralis			P				W		2
Eleutherodactylus saltuarius			R						1
Eleutherodactylus stadelmani			W		W				2
Leptodactylus silvanimbus		W							1
Hypopachus barberi		W							1
Hypopachus variolosus								P	1

Continued on page 43.

Table 3. Continued.

Species	SE HL	SW HL	N-Central HL	Yoro HL	Ocote HL	Agalta HL	NW HL	Santa Bárbara HL	Total
Rana berlandieri[2]	W	W					P	P	4
Rana maculata	W	W	P		P		W		5
Abronia montecristoi							R		1
Abronia salvadorensis		W							1
Celestus bivitattus		P							1
Celestus montanus							P		1
Celestus scansorius			R						1
Mesaspis moreletii	W	W			W		W		4
Sceloporus malachiticus	W	W	W	P	P	W	W		7
Norops amplisquamosus							R		1
Norops crassulus		W							1
Norops cusuco							R		1
Norops heteropholidotus		R							1
Norops johnmeyeri							W		1
Norops kreutzi			R						1
Norops laeviventris	P	P					P	W	4
Norops loveridgei			W						1
Norops muralla					X	X			2
Norops ocelloscapularis							P		1
Norops petersii							R		1
Norops pijolensis			W						1
Norops purpurgularis			R						1
Norops rubribarbaris								R	1
Norops sminthus	W								1
Norops tropidonotus	P		P		W				3
Norops uniformis							P		1
Norops yoroensis			P	P					2
Sphenomorphus cherriei	P				P		P		3
Sphenomorphus incertus			P						1
Typhlops stadelmani							P		1
Boa constrictor							P		1
Adelphicos quadrivirgatus							P		1
Coniophanes bipunctatus							P		1
Dryadophis dorsalis		W	W	P	P		P		5
Drymarchon corais							P		1
Drymobius chloroticus	P	P	W				W		4
Drymobius margaritiferus							P		1
Geophis damiani			R						1
Geophis fulvoguttatus		W					W		2
Imantodes cenchoa			P		P		P		3
Lampropeltis triangulum							P		1
Leptodeira septentrionalis		W	W				P		3
Leptophis ahaetulla					W		W		2
Leptophis modestus		R							1
Ninia diademata							P		1
Ninia espinali		W					W		2
Ninia sebae								P	1
Pliocercus elapoides			P		W		P		3
Rhadinaea godmani	W	W	W						3
Rhadinaea kinkelini		W	W				P		3
Rhadinaea lachrymans						R			1
Rhadinaea montecristi		W					W		2
Rhadinaea tolpanorum			R						1
Sibon dimidiatus							P		1
Sibon nebulatus			W						1

Continued on page 44.

Table 3. Continued.

Species	SE HL	SW HL	N-Central HL	Yoro HL	Ocote HL	Agalta HL	NW HL	Santa Bárbara HL	Total
Stenorrhina degenhardtii					P		P		2
Storeria dekayi		P							1
Tantilla impensa							W		1
Tantilla lempira		P							1
Tantilla schistosa							W		1
Thamnophis fulvus	P	W							2
Tropidodipsas fischeri		W							1
Micrurus browni		R							1
Micrurus diastema							W		1
Micrurus nigrocinctus			P						1
Bothriechis marchi			P				W		2
Bothriechis thalassinus		P					W	P	3
Cerrophidion godmani	W	W	W				W		4
Totals	**19**	**39**	**39**	**5**	**21**	**4**	**60**	**11**	**–**

[1]North-Central Highlands records based on calling males that could not be located.
[2]*Rana berlandieri* from the Southeastern and Southwestern Highlands equal *R. berlandieri* x *R. forreri* (see McCranie and Wilson 2002).
DOI: 10.1514/journal.arc.0000013.t003

D. Northern terminus of the range in Mexico north of the Isthmus of Tehuantepec and southern terminus in South America.
E. Northern terminus of the range in Mexico north of the Isthmus of Tehuantepec and southern terminus in Central America south of the Nicaraguan Depression.
F. Northern terminus of the range in Mexico north of the Isthmus of Tehuantepec and southern terminus in Nuclear Middle America.
G. Northern terminus of the range in Nuclear Middle America and southern terminus in South America.
H. Northern terminus of the range in Nuclear Middle America and southern terminus in Central America south of the Nicaraguan Depression.
I. Restricted to Nuclear Middle America (exclusive of Honduran endemics).
J. Endemic to Honduras.

The data on broad distributional patterns in Table 1 are summarized in Table 2. These data indicate that the largest number of species (48 or 39.3% of the total of 122 species) fall into the J category, i.e., that containing the species endemic to Honduras. The next largest category is I, with 35 species (28.7%), containing those species not endemic to Honduras but restricted in distribution to Nuclear Middle America. Together, these two categories contain 68.0% of the cloud forest species. The other eight categories contain from one to ten species and harbor, as a group, 32.0% of the total number. These data again point to the biogeographic and conservation importance of the Honduran cloud forest herpetofauna.

Primary microhabitat distribution

We used the same microhabitat categorization as did Espinal et al. (2001). In terms of vertical positioning, we scored species as either terrestrial or arboreal. With respect to occurrence in the three major microhabitats found in cloud forest, species were scored as being found in the forest proper, along streams, or around ponds (Table 1).

In terms of vertical positioning within the primary microhabitats, 49 species (40.2%) were usually found only in arboreal situations, 62 species (50.8%) only in terrestrial situations, and 11 (9.0%) in both. With respect to occurrence in the three major microhabitats (forest proper, streamside, pondside), 76 species (62.3%) were found exclusively in the forest proper, 26 (21.3%) only along streams, eight (6.6%) only around ponds, seven (5.7%) in the forest and along streams, three (2.5%) around ponds and along streams, and two (1.6%) in the forest and around ponds (Table 1).

If the two sets of categories, vertical positioning in primary habitat and microhabitats, are combined, it can be demonstrated that 94 species (77.0%) fall into four groups, as follows (Table 1): 40 terrestrial forest inhabitants (32.8%); 31 arboreal forest inhabitants (25.4%); 12 arboreal streamside inhabitants (9.8%); and 11 terrestrial streamside inhabitants (9.0%). The terrestrial forest inhabitants include four salamanders, four anurans, four lizards, and 28 snakes. The arboreal forest inhabitants are eight salamanders, two anurans, 19 lizards, and two snakes. The arboreal streamside inhabitants are one salamander, nine anurans, and two snakes. The terrestrial streamside inhabitants are ten anurans and one lizard.

Relative abundance

In discussing relative abundance, we used the following categorization: common (C: found on a regular basis, many individuals can be found); infrequent (I: unpredictable, few individuals seen); rare (R: rarely seen). These classifications are historical (i.e., based largely on earlier trips to cloud forest localities) and do not take into consideration the population declines taking place for many species (see *Biodiversity significance and conservation status of the cloud forest herpetofauna*). Sixty-three species (51.6%) are classified as being common (11 salaman-

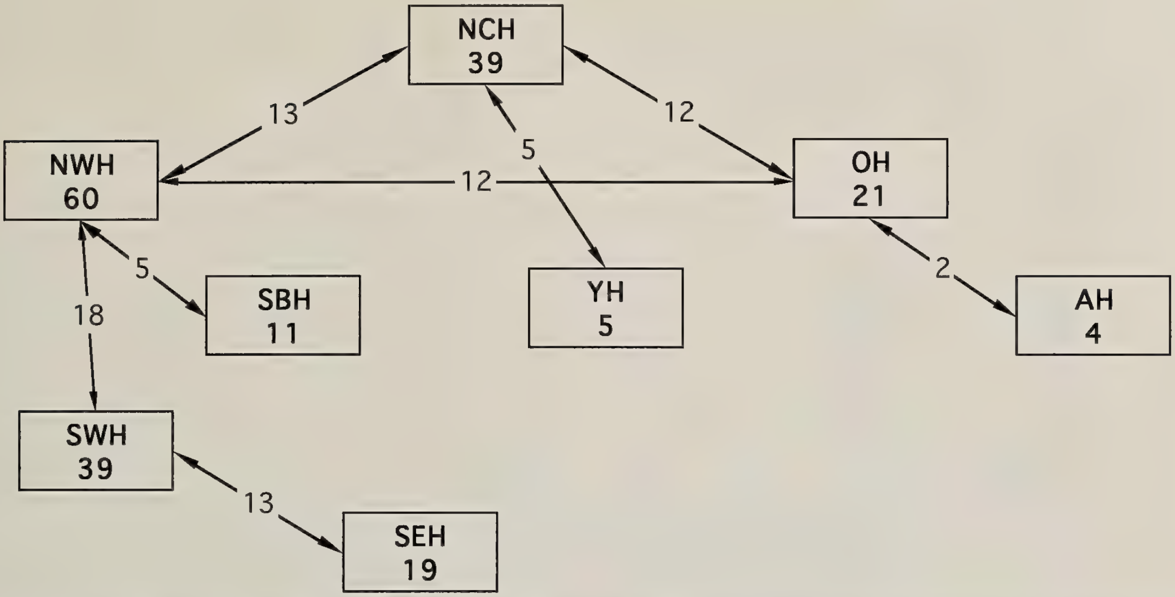

Figure 2. Greatest shared species diagram of eight cloud forest areas in Honduras. See text for explanation of abbreviations. Numbers in boxes are the number of species in each area; numbers on arrows indicate the number of species shared between areas connected and represent the greatest shared value for each area. Position of the boxes in the diagram is roughly reflective of their geographic relationships in Honduras.
DOI: 10.1514/journal.arc.0000013.g002

ders, 28 anurans, 15 lizards, and nine snakes), 37 (30.3%) as being infrequent (five salamanders, six anurans, five lizards, and 21 snakes), and 22 (18.0%) as being rare (two salamanders, four anurans, seven lizards, and nine snakes).

Patterns of distribution among ecophysiographic areas

Wilson et al. (2001) recognized eight ecophysiographic areas that contain cloud forest vegetation. Two of these areas, the Southeastern Highlands and Southwestern Highlands, are located in the Southern Cordillera. The remaining six areas are situated in the Northern Cordillera. The distribution of the members of the Honduran cloud forest herpetofauna among these eight cloud forest ecophysiographic areas is indicated in Table 3. Perusal of the data in this table allows for several conclusions, as follows:

1. The numbers of species in these eight areas range from four (Agalta Highlands) to 60 (Northwestern Highlands).
2. Significantly more species are known from the Northern Cordillera areas (98 or 80.3% of total) than those in the Southern Cordillera (45 or 36.9%) areas. Only 20 species (16.4%) are distributed in both cordilleras (the *Rana berlandieri* listed in Table 3 from the Southern Cordillera are considered *R. berlandieri* x *R. forreri* hybrids—see McCranie and Wilson 2002).
3. The above pattern is seen in each of the major herpetofaunal groupings. Only four salamanders are found in the Southern Cordillera cloud forests, compared to 15 in the Northern Cordillera cloud forests. Only a single species (*Bolitoglossa conanti*) is distributed in both cordilleras (although the population in the Southern Cordillera likely represents an undescribed species). Fifteen species of anurans occur in the Southern Cordillera cloud forests, as opposed to 28 in the Northern Cordillera forests. Only four species (*Plectrohyla guatemalensis, P. matudai, Ptychohyla hypomykter,* and *Rana maculata*; the

Table 4. CBR matrix of herpetofaunal relationships for the eight ecophysiographic areas supporting cloud forest. **N** = species in each region; N = species in common between two regions; <u>N</u> = Coefficients of Biogeographic Resemblance. See text for explanation of the abbreviations. No distinction is made between *Rana berlandieri* and *R. berlandieri* x *R. forreri* for this analysis.

	SEH	SWH	NCH	YH	OH	AH	NWH	SBH
SEH	**19**	13	7	1	7	1	10	2
SWH	0.45	**39**	9	2	6	1	18	2
NCH	0.24	0.23	**39**	5	12	1	13	1
YH	0.08	0.09	0.23	**5**	4	1	3	1
OH	0.35	0.20	0.40	0.31	**21**	2	12	1
AH	0.09	0.05	0.05	0.22	0.16	**4**	1	0
NWH	0.25	0.36	0.26	0.09	0.30	0.03	**60**	5
SBH	0.13	0.08	0.04	0.13	0.06	0.00	0.14	**11**

DOI: 10.1514/journal.arc.0000013.t004

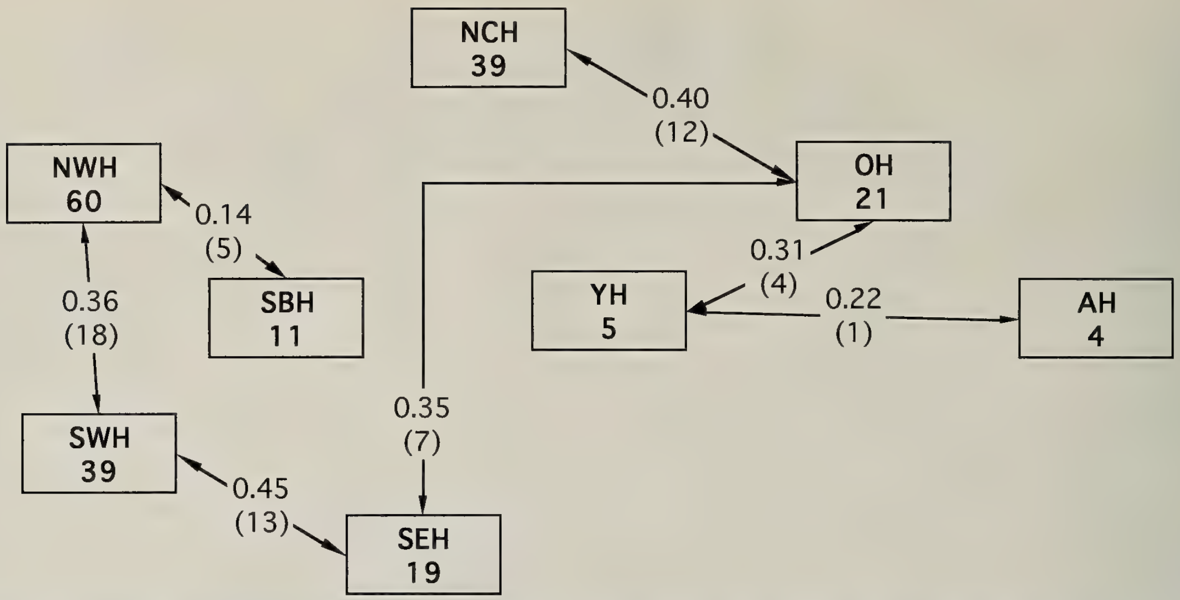

Figure 3. Coefficient of Biogeographic Resemblance diagram for the eight cloud forest areas in Honduras. See text for explanations of abbreviations. Numbers in boxes are the number of species in each area; decimal numbers on arrows indicate the CBR value shared between areas connected and represent the highest value for each area; absolute numbers in parentheses indicate the number of species shared between the areas connected. Position of the boxes in the diagram is roughly reflective of their geographic relationships in Honduras.
DOI: 10.1514/journal.arc.0000013.g003

Rana berlandieri listed in Table 3 from the Southern Cordillera are considered *R. berlandieri* x *R. forreri* hybrids—see McCranie and Wilson 2002) occur in both regions. Ten species of lizards are distributed in the Southern Cordillera forests, whereas 22 are in the Northern Cordillera forests. Only five species (*Mesaspis moreletii, Sceloporus malachiticus, Norops laeviventris, N. tropidonotus,* and *Sphenomorphus cherriei*) are found in both areas. Finally, 16 species of snakes occupy the Southern Cordillera cloud forests and 33 the Northern Cordillera forests. Ten species (*Dryadophis dorsalis, Drymobius chloroticus, Geophis fulvoguttatus, Leptodeira septentrionalis, Ninia espinali, Rhadinaea godmani, R. kinkelini, R. montecristi, Bothriechis thalassinus,* and *Cerrophidion godmani*) are distributed in both areas.

4. Most of the 122 species (102 or 83.6%) occur in only one or two cloud forest ecophysiographic areas. The most broadly-distributed species occur in seven ecophysiographic areas (*Sceloporus malachiticus*) or in five ecophysiographic areas (*Plectrohyla guatemalensis, Smilisca baudinii, Rana maculata,* and *Dryadophis dorsalis*). The average area occurrence is 1.6.

A greatest shared species diagram of the eight cloud forest physiographic areas is presented in Figure 2. The areas are abbreviated as follows: Southeastern Highlands - SEH; Southwestern Highlands - SWH; North-Central Highlands - NCH; Yoro Highlands - YH; Ocote Highlands - OH; Agalta Highlands - AH; Northwestern Highlands - NWH; Santa Bárbara Highlands - SBH. The number of species shared between areas ranges from two to 18. In general, the greater the total herpetofaunas of any two compared areas, the greater is the number of species shared.

Generation of Coefficient of Biogeographic Resemblance (CBR) values allows for a more robust analysis of herpetofaunal resemblances. Thus, a matrix of CBR values for the eight ecophysiographic areas is summarized in Table 4, and these values are used to produce a CBR diagram (Fig. 3) indicating highest values for each ecophysiographic area. These values indicate that the herpetofauna of a given ecophysiographic area most closely resembles that of another area occupied by the same forest formation and/or lying in close geographic proximity. For example, the Southeastern Highlands and the Southwestern Highlands are both occupied by the Lower Montane Moist Forest formation and they share 13 species. Also, as an example, the Northwestern Highlands and the Southwestern Highlands are in close geographic proximity and share 18 species. Geographic proximity, however, appears to be the more important determinant of the degree of herpetofaunal resemblance, inasmuch as Figure 3 illustrates a western and southern grouping of areas (NWH, SBH, SWH, and SEH) and a northern and eastern grouping of areas (NCH, OH, YH, and AH). These two groups are connected by a relatively high CBR value between SEH and OH.

Averaging all CBR values provides a gauge of herpetofaunal distinctiveness, as follows: SEH (0.23); SWH (0.21); NCH (0.21); YH (0.16); OH (0.25); AH (0.09); NWH (0.20); SBH (0.08). The most distinctive herpetofauna is that of the SBH (average CBR value of 0.08), the least that of the OH (average CBR value of 0.25). The distinctiveness of the SBH herpetofauna is an artifact of being poorly known. The fewer the species known from a given area, the fewer there are to be shared with other areas.

Biodiversity significance and conservation status of the cloud forest herpetofauna

As noted in the Introduction, the herpetofauna of Honduras is being subjected to the same anthropogenic pressures as have been demonstrated to be in effect elsewhere in the tropics. The most substantial pressure is created by habitat loss as a result of deforestation (Wilson et al. 2001; Wilson and McCranie 2003 a and b). Also significant is a threat of unsubstantiated origin (but see Duellman 2001, for a discussion of events elsewhere in the tropics) that is decimating amphibian populations in the country occurring at elevations in excess of 900 m (Wilson and McCranie 1998; McCranie and Wilson 2002), thus conceivably impacting all cloud forest areas.

That these threats are impinging on herpetofaunal populations at 900 m and above is especially poignant, inasmuch as the herpetodiversity of greatest significance is distributed in these regions, especially those supporting cloud forest. This most significant herpetodiversity consists of those species endemic to Honduras and those otherwise restricted to Nuclear Middle America. Of the 334 species now known to constitute the Honduran herpetofauna (including six marine reptiles), 78 are country endemics (23.4% of total) and 47 are Nuclear Middle American-restricted species (14.1%). A greater percentage of the amphibian species fall into these two categories than do the reptilian species. There are 41 amphibian Honduran endemics (35.0% of total of 117 species) and 25 Nuclear Middle American-restricted amphibian species (21.4%), compared to 37 (17.1% of total of 217 species) and 22 (10.1%) such reptilian species, respectively. Thus, a total of 125 species of amphibians and reptiles (37.4%) are either endemic to Honduras or otherwise restricted to Nuclear Middle America.

Of these 125 species, 83 or 66.4% are distributed in cloud forests in Honduras (Table 2). Of the remaining 209 Honduran species not found in cloud forests, only 42 species or 20.1% are Honduran endemics or Nuclear Middle American-restricted. It is obvious that the large majority of the species of greatest biodiversity significance is found in cloud forests.

As indicated above, deforestation is eroding forest resources throughout the country. Wilson and McCranie (2003 a) presented estimates, based on a computer model in E. Wilson and Perlman (2000), suggesting that the current deforestation rate is -2.3%, giving rise to a halving rate of 30.1 years. At this rate, only a half a million hectares of forest will remain in Honduras by the year 2085 and none will remain by the end of the current century.

This trend has been affecting cloud forests in Honduras, just as it has everywhere else in the country, and continues to the present day. It has been abated somewhat by the establishment of biotic reserves in several of the ranges supporting cloud forest (Wilson et al. 2001). This establishment largely has been the result of an effort to secure water supplies for populated areas. As noted by Wilson et al. (2001), however, most of these reserves are incompletely developed, such that deforestation still proceeds in many, if not all of them (e.g., Espinal et al. 2001), as a result of illegal logging and subsistence farming.

It has been demonstrated in recent years that populations of many Honduran amphibians and reptiles are in decline or have disappeared altogether, as part of a global pattern (Duellman 2001). Wilson and McCranie (2003 a) have provided the most recent assessment of this trend for the Honduran herpetofauna. However, their assessment differs somewhat from the one undertaken here. Wilson and McCranie (2003 a) considered the range as a whole for each species when classifying whether a given species had stable populations somewhere in their range. However, a few species may have stable populations at some low elevation localities, but may be extirpated from their known cloud forest localities (e.g., *Eleutherodactylus charadra*). Thus, the conservation status categories in this paper refer only to cloud forest populations. Table 1 lists the conservation status for each of the 122 species at their known cloud forest localities. These data indicate that 40 species (32.8%) have populations that are in decline, eight species (6.6%) have disappeared altogether from cloud forests, and 16 species (13.1%) are too poorly known to determine their status in Honduran cloud forests. Fifty-eight species (47.5%) appear to have stable populations in at least one cloud forest locality.

When one considers only the two most important components of the Honduran cloud forests (the Honduran endemics and the Nuclear Middle American-restricted species), then 15 of the 48 Honduran endemics (31.3%) have declining populations, six endemics (12.5%) have disappeared, five endemics (10.4%) are too poorly known to determine their status, and 22 endemics (45.8%) appear to have stable populations in at least one cloud forest locality. Of the 35 Nuclear Middle American-restricted species, 20 (57.1%) have declining populations, one (2.9%) has disappeared, two (5.7%) are too poorly known, and 12 (34.3%) appear to have stable populations in at least one cloud forest locality. Thus, about one half of the 83 Honduran endemics or Nuclear Middle American-restricted species have declining populations (35 species or 42.2%) or have disappeared from Honduran cloud forests (seven species or 8.4%). Of the six Honduran endemic species that have disappeared from cloud forests, five are feared extinct. These are shocking statistics, considering the importance of these species not only biologically, but also from conservation and ecotourist standpoints.

From simply a biological standpoint, the systematics of the majority of the 83 cloud forest notables (Honduran endemics and Nuclear Middle American-restricted species) are insufficiently understood to be subjected to cladistic analysis, a requirement for reconstructing their phylogenies, and, beyond this, their biogeographic histories. These species are particularly important in our effort to understand the general patterns of evolution of the herpetofauna and to take that understanding beyond the work done on this subject to date.

From the perspective of conservation biology, we have demonstrated here and elsewhere (Wilson and McCranie 1998, 2003 a and b; Wilson et al. 2001; McCranie and Wilson 2002, *in press*) that the herpetofauna is anything but the pedestrian compendium alluded to in Lynch and Fugler's (1965, p.15) conclusions when they wrote that, "The anuran fauna seems to be derived from largely widespread species and species with northern affinities." Quite to the contrary, the work that has been accomplished since Lynch and Fugler published their paper 38 years ago has shown that slightly more than a third (37.4%) of the Honduran herpetofauna is com-

posed of endemics or otherwise Nuclear Middle American-restricted species. Our work in cloud forests has provided the major support for that conclusion.

The economic value of the Honduran cloud forests for ecotourism is only beginning to be calculated. It is stunningly evident to us, however, based on the several decades of our field work in the country, that efforts to develop an ecotourist-generated component to the Honduran economy is likely to be doomed by the uncontrolled human population growth that continues to stymie efforts to conserve the considerable biodiversity of the country.

Acknowledgments.—Over the decades that we have worked on the cloud forest herpetofauna in Honduras, we have become indebted to innumerable individuals and organizations. First and foremost, this work could not have been accomplished without the support of the personnel of the governmental agencies Recursos Naturales Renovables and Corporación Hondureña de Desarrollo Forestal (COHDEFOR), who made the necessary collecting and export permits available to us over the years. In addition, our inestimable friend Mario R. Espinal has acted as our agent in Honduras in assuring that the garnering of these permits went as smoothly as possible, that vehicles were ready when we needed them, and that other myriad details upon which the success of our field work depended were appropriately handled. Finally, it has been our great and continuing pleasure to work with uncounted Hondurans who have made us *gringos* feel at home in Honduras. Without the unflagging efforts of these friends, we would never have unearthed the secrets of the amphibians and reptiles to which we have devoted our scientific lives.

We also extend our gratitude to Nidia Romer, who graciously translated the Abstract into Spanish for use as the Resumen. We are also grateful to Louis Porras and Jay M. Savage, the reviewers of this paper, for their improvements.

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Manuscript received: 14 January 2002; Accepted: 4 April 2002
Published online: October 2003; Printed: January 2004

SCOPE: **Amphibian and Reptile Conservation** (ISSN: 1083-446X) **[ARC]** and the accompanying online edition (ISSN: 1525-9153) is a popularly accessible, peer-reviewed scientific journal of international scope, which is devoted to the worldwide preservation and management of amphibian and reptilian diversity. ONLINE EDITION: The full-text online edition is available FREE-OF-CHARGE as PDF (Portable Document Format) and HTML files at: www.pubmedcentral.nih.gov/. AUDIENCE: **ARC** is intended for a wide readership from nonprofessional to professional herpetologists, the general public, and scientists. FREQUENCY: **ARC** publishes two issues per year (semi-annually). FOCUS: **ARC** concentrates on publishing timely information in the form of feature articles, original papers and data, reviews, reports, short communications, columns, commentaries, book reviews, editorials, and news and notes. DISTRIBUTION: **ARC** is an open access journal which can, with absolutely no restrictions and/or site registration, be freely accessed (no charge) by anyone with an Internet connection and web browser. The print edition is also available worldwide by subscription as well as quality newsstands, bookstores, and select vendors. Delivery is guaranteed. PUBLISHER: Craig Hassapakis, **Amphibian and Reptile Conservation**, 2525 Iowa Avenue, Modesto, California 95358-9467, USA; email: publisher@herpetofauna.org; website: www.herpetofauna.org. POSTMASTER: Please send change of address to **ARC** eight weeks prior to move. COPYRIGHT: All works published in **ARC** are open access, subject to the terms of the Creative Commons Attribution License (http://creativecommons.org/license/by/1.0). Copyright is retained by the author(s). COMMUNICATION: It is recommended that all correspondence be conducted via email: ARC@herpetofauna.org whenever possible. All other types of correspondence should be directed to **ARC** using the contact information above (see under publisher). SUBSCRIPTIONS: All paid subscribers receive four consecutively distributed print issues received by postal mail. CATEGORIES: Subscription rate categories are Individual $25 and Institutional $50 (both include postage). All subscriptions outside the US include $15 for shipping and handling to regular subscription rate (Non-US rate: Individual $40 and Institutional $65). BACK ISSUES: Individual copies are available from the publisher for $15 each (Note: Volume 1, Number 1 is out-of-print). Facsimiles (photocopies) are available once issues are out-of-print. Copies of individual articles can be purchased on request; please inquire. DONATIONS: Contributions for the journal are gladly accepted. These specific resources are used to further the conservation of amphibians and reptiles with the goals of the journal. CATEGORIES INCLUDE: Friends of **ARC** $40, Supporting $60, Contributing $100, Patron $250, Sustaining $500, and Founder (includes lifetime subscription to **ARC**) $1,000. All other contributors, excluding Founders, receive four consecutively distributed issues. PAYMENT: All journal orders must be paid in US currency drawn on a US bank (check or international money order). WEBSITE: www.herpetofauna.org. PRODUCTION: Manufactured and printed in the United States of America using recycled paper and soy based inks.

AMPHIBIAN & REPTILE CONSERVATION

THE INTERNATIONAL JOURNAL DEVOTED TO THE WORLDWIDE PRESERVATION AND MANAGEMENT OF AMPHIBIAN AND REPTILIAN DIVERSITY

VOLUME 3 ISSN: 1083-446X eISSN: 1525-9153 NUMBER 1

SPECIAL FEATURE—HONDURAS

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EDITORIAL

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Duellmanohyla soralia. A Nuclear Middle American Restricted Species with all known Honduran populations believed to be declining. *Photo credit: kindly provided by James R. McCranie.*

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Indexed by: Biological Abstracts and Zoological Record